INSTRUCTION MANUAL

FOR MODEL XYY 540
RECORDER

SERIAL No. 961203

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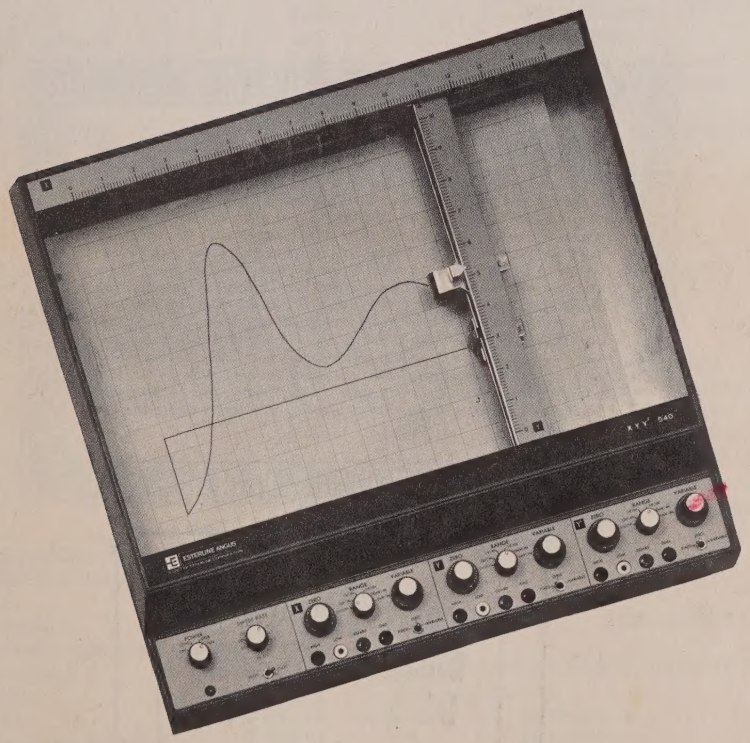

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SECTION 1
GENERAL INFORMATION

1-1. INTRODUCTION

This manual provides operation instructions and maintenance information for the Model 540 Series of X-Y-Y' Recorders. Information covering installation, operation, principles of operation, and maintenance procedures is provided in Sections 2 through 5. An illustrated parts breakdown and schematic are included in Section 6.

1-2. DESCRIPTION

There are four Models in the 540 Series: 540, 540T, 540M, and 540TM. Models 540M and 540TM are calibrated in metric units. Specific details which apply only to metric models have been enclosed in parentheses in the text of the manual and on the schematic.

The recorders are designed to produce an X-Y and/or an X-Y' Cartesian coordinate graph showing the relationship between two or three dc or low frequency ac voltages. On Models 540T and 540TM, an accurate built in time base generator or SWEEP may be used on any of the axes to record a time relationship.

The resultant plots are made in ink on either 8-1/2 x 11 inch (21.6 x 28 centimeter), or 11 x 16-1/2 inch (28 x 42 centimeter) graph paper.

All Models of the 540 Series may be operated from either a 115 Vac or 230 Vac power line, and may also be either bench or rack mounted. Instructions for line voltage selection and rack installation are in Section 2.

A. ACCESSORIES

Each recorder is supplied with the following items:

1. A plastic dust cover.

2. A remote mating connector.

3. One box of large size graph paper. English or metric markings depending on the unit ordered.

4. An accessory kit containing:

   a. Six green disposable markers.

   b. Six red disposable markers.

   c. A package containing all Allen wrenches required.

5. Two rack mounting flanges (upon order).

6. Instruction Manual.

B. OPTIONAL EQUIPMENT

The following options are available at additional cost:

1. Recorder Service Stands: Right and left side stands which hold the recorder in a vertical position with the bottom cover removed and the circuit card rotated for calibration or maintenance.

2. Retransmitting Potentiometers: Available for any or all axes to provide a means of electronically sensing the position of the axis for use in associated equipment. The potentiometers are 5 KΩ and ±0.1% linearity.

3. Potentiometric Input: Available for any or all axes to provide a high input resistance for the two most sensitive ranges. This higher resistance, typically 50 MegΩ, permits the use of higher resistance sources without loading errors.

1-3. SPECIFICATIONS

A. PHYSICAL

1. Weight: 30 pounds.

2. Dimensions: 17-1/2 inches high, 19 inches wide, 7-3/8 inches deep.

B. ENVIRONMENTAL

1. Ambient Temperature: Operating: 10 to 40°C (50 to 104°F). Non-operating: -20 to 70°C (-4 to 158°F).

2. Humidity: 75% maximum, relative, noncondensing.

Humidity affects the graph paper to a greater degree than it does the recorder. Relative humidity above 70% or below 30% can cause up to 1% error in the accuracy of the paper.

C. POWER REQUIREMENTS

1. Voltage: 115 ±10 V or 230 ±20 V.

2. Frequency: 48 to 62 Hz.

3. Power Consumption: 60 W typical.

D. RECORDING SYSTEM

1. Paper Size:

Table 1-1. Paper Dimensions

	Large		Small	
	Outside	Graph	Outside	Graph
In.	11 x 16-1/2	10 x 15	8-1/2 x 11	7 x 10
Cm	28 x 42	25 x 38	21.6 x 28	18 x 25

2. Accuracy: ±0.2% of full scale, throughout the range of operating environmental and power variations, and up to a writing speed of 2 inches/second.

a. Repeatability: ±0.1% of full scale.

b. Linearity: ±0.1% of full scale.

c. Dead Band: ±0.1% of full scale.

3. Frequency Response: Dc to 5 Hz ±3 db (1 inch P-P sine wave).

4. Transient Response: Step Input with 8 inch deflection.

a. Delay Time: 100 milliseconds maximum to reach 10% of output amplitude.

b. Slewing Speed: 30 in/sec (75 cm/sec), typical all axes. 25 in/sec (63 cm/sec) minimum.

c. Overshoot: 2% of full scale, maximum for Y and Y' axes; 3% of full scale, maximum, for X axis.

5. Zero Offset: ± Full scale suppression.

6. Trace Separation: 0.10 inch maximum.

7. Input Voltage Ranges: Five calibrated ranges with VARIABLE control for continuous adjustment between ranges: 1 mV/IN, 10 mV/IN, .1 V/IN, 1 V/IN, 10 V/IN (.5 mV/CM, 5 mV/CM, 50 mV/CM, .5 V/CM, 5 V/CM).

8. Maximum Input: 10 Vdc or peak ac on 1 mV/IN and 10 mV/IN (.5 mV/CM and 5 mV/CM) ranges. 500 Vdc or peak ac on all other ranges.

9. Input Impedance: 1 Megohm on all ranges, fixed or variable, "on" or "off null."

10. Input Circuits: Floating, Guarded and Differential.

11. Common Mode Rejection:

a. Dc: 130 db at 1 mV/IN (.5 mV/CM) decreasing to 50 db at 10 V/IN (5 V/CM).

b. Line Frequency: 110 db at 1 mV/IN (.5 mV/CM) decreasing to 30 db at 10 V/IN (5 V/CM).

12. Maximum Common Mode Voltage: 500 Vdc or peak ac.

13. Sweep (540T and 540TM):

a. Accuracy:

1) Short Term: ±1% of full scale, over a temperature span of 5°C, humidity span of 5%, and a line voltage span of 5%, at all sweep rates.

2) Long Term: ±2% of full scale, over the range of temperature and line voltage variations, at all sweep rates.

3) Linearity: ±1% of full scale.

b. Rates: .01, .02, .05, .1, .2, .5, 1, and 2 IN/SEC (.02, .05, .1, .2, .5, 1, 2, and 5 CM/SEC).

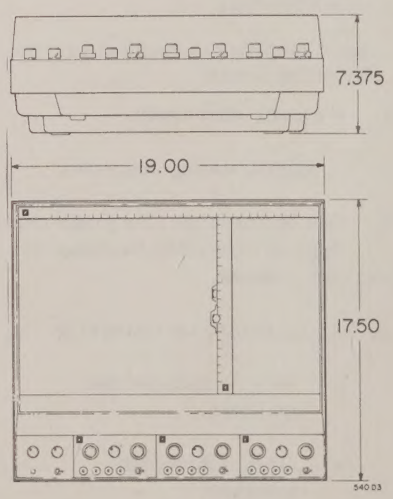


Figure 1-1. Outline and Dimensions

SECTION 2
INSTALLATION

2-1. GENERAL

This section provides information on the installation and check-out of the Model 540 Series X-Y-Y' Recorders. Information on unpacking, repacking, and damage claim procedures is also provided.

2-2. UNPACKING

No special instructions for unpacking are required, except to use reasonable care. After unpacking, carefully inspect the case, controls, and connectors for any visible evidence of shipping damage. In the event that there is damage, immediately notify carrier and an Esterline Angus representative.

2-3. INSTALLATION

A. AC POWER INPUT

Recorders of the Model 540 Series may be operated on either 115 Vac or 230 Vac facility power. Recorders are normally shipped set up for 115 Vac operation unless otherwise specified. To change from one operating voltage to the other, follow the procedure below:

1. Remove the bottom cover. See Paragraph 5-2. A.
2. Set the slide switch on the circuit board next to the transformer to the desired voltage.
3. Insert the proper fuse: 0. 75 amp, Slo-Blo for 230 Vac; 1. 5 amp, Slo-Blo for 115 Vac.
4. Replace the bottom cover.
5. Connect the power cord to facility power.
6. Ensure that the third prong of the plug is grounded at the outlet for proper operation.

Note

All recorders are supplied with a standard three prong 115 Vac plug. Customer replacement of this plug will be required if non-standard receptacles or 230 Vac power is utilized.

B. MOUNTING

1. Bench mounting of the recorder requires only sufficient horizontal space and a nearby power outlet. The bail stand on the bottom of the recorder may be extended if a slightly tilted position is desired.

2. To mount the recorder in a standard 19 inch wide instrument rack, proceed as follows:

a. Attach the mounting ears to the side flanges as they are shown in Figure 2-1.

b. Align the flanges with the holes in the instrument rack, and secure the flanges to the rack.

c. Position the recorder so that the ears slide into the slots in the recorder frame.

d. Secure the recorder by inserting set screws through the sides of the recorder into the mounting ears.

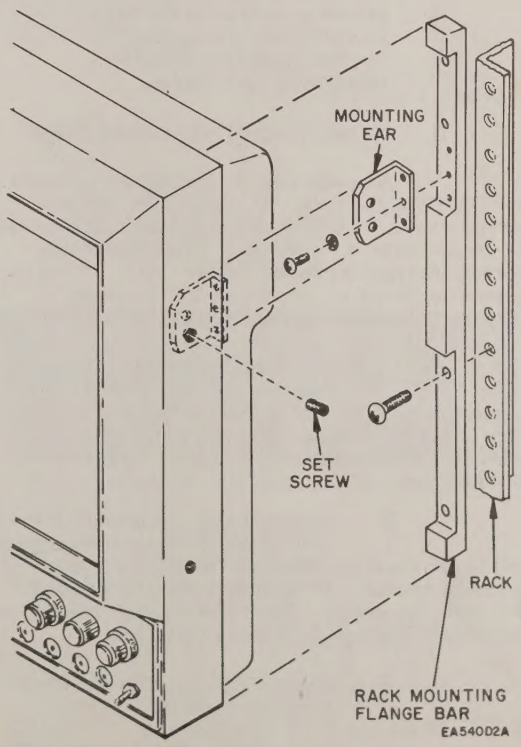


Figure 2-1. Rack Mounting

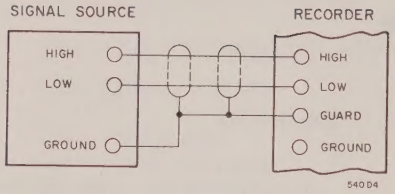


Figure 2-2. Differential Input Connection

C. SIGNAL INPUTS AND GROUNDING

The input signal common terminal LOW is isolated from chassis ground within the recorder to permit floating measurements. Signal commons of the X, Y, and Y' inputs are also isolated from each other to provide alternate methods of input signal ground termination. Figure 2-2 illustrates the differential input connections. This set-up is recommended where long input cables are used or common mode voltages are encountered and provides the best noise-free operation. Single-ended input connections are illustrated in Figure 2-3. If the signal source low and signal source ground are common, the jumper between LOW and GND on the recorder should not be installed.

Note

The GUARD terminal must be connected to the signal source ground or to the recorder LOW terminal; in no case should the GUARD terminal be left floating.

D. REMOTE CONTROL CONNECTION

Through remote connector J1, inputs for (1) lifting the pens, (2) starting the optional sweep circuit, and (3) recording event markers may be connected to the recorder. J1 is accessible through the opening in the bottom cover. A mating connector for J1 is supplied in the accessory kit. The remote connections are made as described below.

1. Pen: A closure between pins 3 and 5 of J1 will raise the pens. A closure between pins 4 and 5 will lower the pens. For remote operation of the pen lift solenoid the POWER switch must be in either the OPERate or the PEN position.

2. Sweep Circuit: A closure between pins 12 and 13 holds the sweep circuit in the reset condition, or resets the sweep if it has been started. An open between pins 12 and 13 will start the sweep. The SWEEP switch must be in the START position for remote operation.

3. Event Markers: The pin connections for event markers are: X - pin 16 and pin 15 (X axis common), Y - pin 10 and pin 9 (Y axis common), Y' - pin 2 and pin 1 (Y' axis common).

Marker sensitivity is 0.66 V/inch for the X axis and 1 V/inch for the Y and Y' axes. A positive voltage produces a negative deflection. The input resistance is 10 K ohms.

2-4. CHECKOUT

Upon completion of installation, check the operation of the recorder by performing the procedure described in Paragraph 3-4.

2-5. PACKING

Should it become necessary to pack the recorder for shipment, it should be packaged as follows:

A. Remove the pen assemblies; secure them in the accessory kit case, and pack the case with the recorder.

B. Secure the carriage. A couple of pieces of tape should prevent any movement of the carriage.

C. Enclose the recorder in a plastic bag or sheet to prevent packaging materials from entering the recorder housing.

D. Place the recorder in a heavy duty corrugated cardboard carton having approximately the same inner dimensions as the recorder.

E. Pack dunnage, rubberized horsehair, or air bubble on all sides of the recorder so that all open spaces are filled and tightly packed.

F. Seal the inner carton and place it in an extra strength outer carton. The outer carton must be large enough to allow a minimum of two inches for dunnage on all sides of the inner pack.

G. Be sure dunnage is packed tightly and that no voids remain.

H. Seal the outer package, mark FRAGILE and THIS SIDE UP to designate normal recorder operating position.

The above packaging must also be in accordance with the regulations and specifications of the carrier to be used.

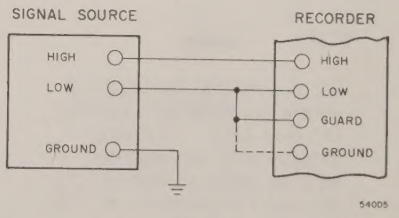


Figure 2-3 Single Ended Input Connection

SECTION 3
OPERATION

3-1. GENERAL

This section provides general operating procedures for the Model 540 Series Recorders. These procedures will provide the operator with a basic understanding of the capabilities of the instrument. With this understanding, the operator should be able to easily adapt the procedures to his specific application.

3-2. CONTROLS AND CONNECTORS

The front panel controls and connectors are shown and described in Figure 3-1. A connector for remote operation is located on the circuit board assembly (See Paragraph 2-3. D).

3-3. PRE-OPERATIONAL PROCEDURES

A. GENERAL

The normal care used when handling any precision instrument should be exercised when operating the recorder. Noisy input signals or improper grounding at the input may result in unpredictable fluctuations in the recorder. If this condition is allowed to persist, it will cause excessive wear in the follow-up potentiometers. Mechanical stops and a slip clutch are provided to prevent damage to the drive mechanism or the follow-up potentiometers if an overrange signal is applied to the input terminals.

CAUTION

In the 1 mV/IN and 10 mV/IN (0. 5 mV/CM and 5 mV/CM) ranges, the input to any axis must not exceed 10 volts. The maximum input for all other ranges is 500 volts.

B. PENS

The fiber tip disposable marker provides a neat, clean inking system. Clogging, blot-

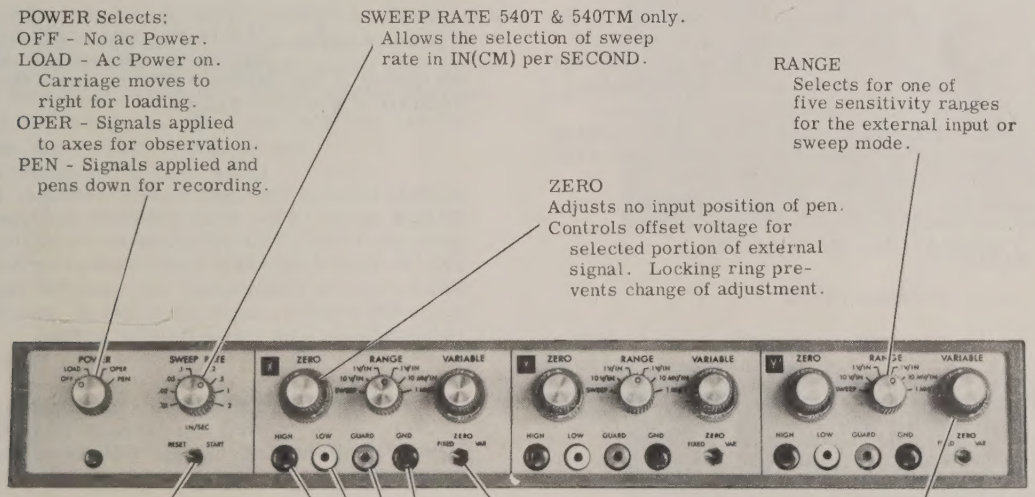

POWER Selects:
OFF - No ac Power.
LOAD - Ac Power on. Carriage moves to right for loading.
OPER - Signals applied to axes for observation.
PEN - Signals applied and pens down for recording.
SWEEP RATE 540T & 540TM only. Allows the selection of sweep rate in IN(CM) per SECOND.
RANGE Selects for one of five sensitivity ranges for the external input or sweep mode.
ZERO Adjusts no input position of pen. Controls offset voltage for selected portion of external signal. Locking ring prevents change of adjustment.
ZERO
RANGE
VARIABLE
HIGH
LOW
GUARD
GND
ZERO FIXED VAR
540 P6
RESET sets the sweep circuit to its "zero" position.
START activates the sweep circuit.
HIGH
LOW
GUARD
& GROUND
Input connectors extend through case for either top or bottom use.
FIXED sets sensitivity to exact RANGE selection.
ZERO disconnects input signal and shorts servo amplifier input.
VAR allows VARIABLE control to decrease sensitivity as desired.
VARIABLE - Adjusts attenuation up to 1/10 of RANGE setting. Locking ring prevents change of adjustment.

Figure 3-1. Series 540 X-Y-Y' Recorder Controls and Connectors

ting, priming, skipping, and the necessity for cleaning have been eliminated. The need for periodic maintenance is virtually eliminated. The only maintenance required is that of maintaining stylus force of approximately 8 to 12 grams maximum to insure maximum cartridge life and minimum tip wear.

1. Changing Cartridges

The disposable marker snaps in for easy installation or removal, with light finger pressure. The Y'-axis pen bracket must be removed from the carriage for marker replacement. The Y axis bracket need not be removed from the machine.

2. Installation

Install the marker as shown in Figure 3-2.

3. Pen Care

The marker ink cap need not be replaced if the recorder is not used overnight. However, it is advisable to replace the cap to prevent drying out if the recorder is not to be used for several days. Should the marker fail to write after periods of non-use, ink flow can be started by moistening the marker tip.

C. PAPER INSERTION AND ALIGNMENT

To insert a sheet of graph paper in the recorder, set the POWER switch to LOAD. This moves the carriage to the extreme right. Align the paper against the stop on the bottom of the plotting area. The large size graph paper is positioned against the paper stop at the left side of the plotting area. The small size paper should be aligned with the inner line on the plotting surface.

3-4. OPERATING PROCEDURE

A. RECORD MODE

1. Set the POWER switch to OFF, and connect the power cord to a suitable ac outlet. Ensure that the receptacle ground has been verified. Do not connect the signal inputs.

2. Set the POWER switch to LOAD. Insert graph paper according to the instructions in Paragraph 3-3. C.

Note

Set the RANGE switches to .1 V/IN (50 mV/CM) or less sensitive for Step 3. More sensitive RANGE settings may produce erratic action due to the unreferenced condition of the preamplifier when the inputs are not connected.

3. Turn the POWER switch to OPERate, and adjust the ZERO controls to position the carriage and pens at the lower left corner of the graph or any other desired "zero" reference point. Use the locking rings to hold this adjustment.

4. Set the FIXED/VARIABLE switches to FIXED, and the RANGE switches to provide for deflections corresponding to the maximum voltages to be recorded. If the ZERO control for any axis has been used to establish an offset or suppressed "zero," a more sensitive RANGE setting may be useful for that axis. See Paragraph 3-4. A. 7.

CAUTION

Be careful not to exceed the maximum allowable input voltage. If the amplitude of the input signal is not known, set the RANGE switch to the least sensitive position 10 V/IN (5 V/CM). An adjustment for greater sensitivity can be made after the signal has been observed in Step 6.

5. If it is desired to have recorder sensitivity correspond exactly to the setting of the RANGE switches, leave the FIXED/VARIABLE switch in FIXED.

If the desired sensitivity is intermediate between the fixed RANGE settings, set the RANGE switch to the more sensitive position and place the FIXED/VARIABLE switch to VARIABLE. The ten-turn VARIABLE control potentiometer may then be used to continuously decrease the sensitivity. In the full counter-clockwise position, sensitivity is reduced to the next lower RANGE setting.

6. Connect the input signals. The pens and carriage will follow the signal variations, but the pens will not be lowered to the paper.

Note

A positive dc signal drives the horizontal X axis to the right and the vertical Y and Y' axes up.

7. If the signal input voltages are greater than the settings of the

[a] To install marker cartridge in Y' axis (upper assembly), lift arrow pointer all the way up until it locks in up position as shown. Remove pen brackets from carriage slider by pulling straight outward from the left. Snap cartridge into clips at bottom of bracket. If desired, the Y axis bracket (lower assembly) may be removed by also pulling outward from the left.

540P8-1A

[b] Reposition bracket on carriage slider as shown. Align bracket slots with the three shouldered standoff on slider, then slowly press bracket inward until end of slots seat under standoffs. Arrow pointer must rest on top of scale decal. On Y axis bracket, see that pointer rests on top of pen-lift bar.

540P8-2A

[c] Slowly push down on Y' pointer as shown until catch releases. Inking systems are now ready for operation.

540P8-3A

Figure 3-2. Pen Assembly Installation

RANGE controls and the desired information is off the recording area, the ZERO controls can be used effectively to select only the desired portion of the input signal and reject the unwanted portion. With these controls in the extreme counter-clockwise positions, negative voltage offsets equal to full scale are provided for recording voltages which vary about high positive dc levels. By means of the ZERO offsets, the effective recording area can be quadrupled.

8. To lower the pens and begin recording set the POWER switch to the PEN position.

B. SWEEP MODE

Models 540T and 540TM permit any one of the axes to be used as a SWEEP axis controlled by a selected rate signal from a built-in time base generator. The other axes, operating in the record mode, are referred to as the signal axes.

1. Perform Steps 1 and 2 of Paragraph 3-4. A.

2. At the axis selected for SWEEP operation, set the RANGE switch to SWEEP and the FIXED/VARIABLE switch to FIXED.

3. Set the RESET/START switch to RESET.

4. Set the POWER switch to PEN. The pens will not lower to the paper.

5. Set the RANGE and VARIABLE controls for the signal axes according to Steps 4 and 5 of Paragraph 3-4. A.

6. Set the SWEEP RATE switch to the desired setting.

7. Adjust the ZERO controls according to Step 3 of Paragraph 3-4. A.

8. Connect the input signals to the appropriate jacks. The signal axes will begin to follow the input variations. The SWEEP axis will remain at its "zero" position.

9. Set the RESET/START switch to START. The pens will lower and begin plotting the external signals as a function of the internal time base.

10. When the SWEEP axis reaches a point where it is desired to reset the sweep, return the RESET/START switch to RESET. This will lift the pens and return the SWEEP axis to its "zero" position.

Note

Failure to RESET the sweep circuit as soon as the sweep is completed will not result in immediate damage to the recorder. However, it should not become a regular practice.

C. REMOTE CONTROL OPERATION

The connections and the procedures required for remote control operations are discussed in Paragraph 2-3. D.

SECTION 4
PRINCIPLES OF OPERATION

4-1. GENERAL

All models of the Series 540 X-Y-Y' Recorders amplify three independent input signals to position recording pens on Cartesian axes by means of dc servo motors.

Models 540T and 540TM are additionally capable of substituting an internally generated time base sweep for the input to any axis in order to plot two external signals in relation to time.

4-2. FUNCTIONAL DESCRIPTION

Figure 4-1 shows a block diagram of the circuitry for each axis of the recorder. Since the circuitry is identical for all three axes, this discussion is limited to the X axis.

Each axis is composed of two functional sections, the input signal conditioning section and the electro-mechanical servo system.

A. SIGNAL CONDITIONING SECTION

The input voltage to be recorded is applied through the input attenuator to the dc preamplifier. The RANGE switch controls both the input attenuator and the local feedback for the preamplifier. On Models 540T and 540TM, the RANGE switch is also utilized to select the SWEEP signal as the axis input. From the pre-amplifier, the signal is routed through the FIXED/VARIABle switch. The FIXED position selects a direct connection to the servo amplifier so that the axis sensitivity corresponds exactly to the RANGE switch position. The VARIABLE position routes the signal through an adjustable voltage divider network to the servo amplifier. The voltage divider network is controlled by the VARIABLE potentiometer which provides continuously adjustable reduction of axis sensitivity. The maximum attenuation provided by the VARIABLE control reduces axis sensitivity to approximately 10% of the RANGE setting.

B. SERVO SYSTEM SECTION

The servo amplifier compares the conditioned input signal and the voltage from the servo feedback attenuator. The feedback voltage represents the actual instantaneous position of the pen in respect to the selected "zero" position. Any difference between these two voltages is amplified and used to drive the servo motor. As the servo motor drives the pen, it also rotates the mechanically linked follow-up potentiometer controlling the feedback voltage. When the input and the feedback are equalized, a balance or "null" condition exists and the drive voltage to the motor ceases. The feedback attenuator also receives a voltage from the ZERO control which is used to establish the "zero" position of the axis as desired. Both

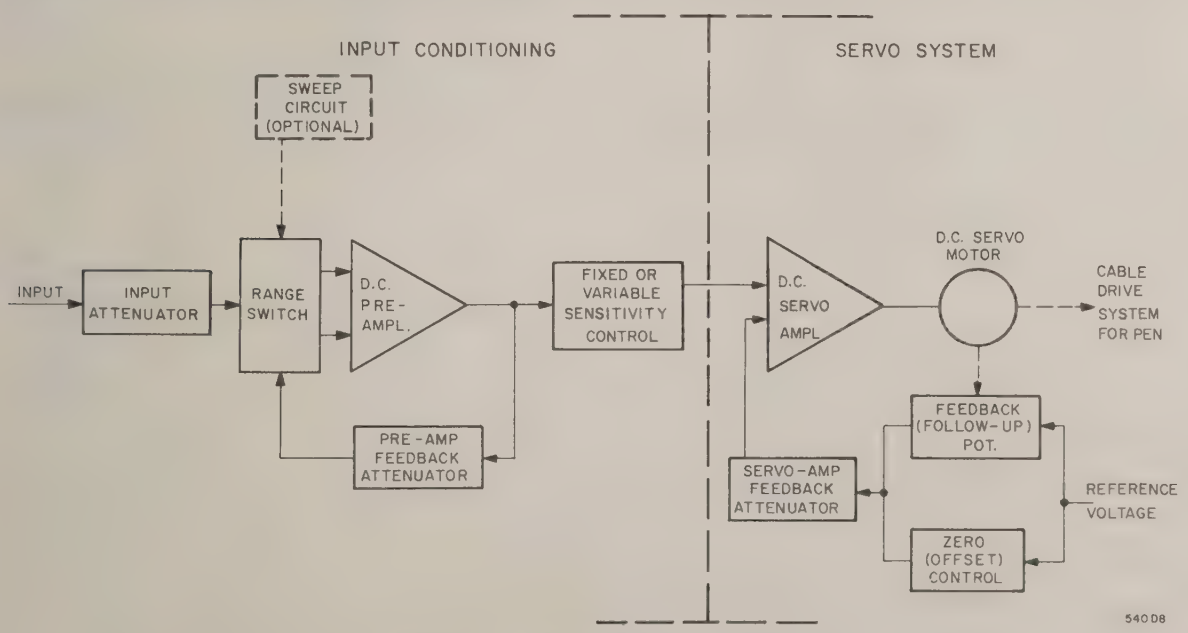


Figure 4-1. Block Diagram of X Axis

the feedback potentiometer and the ZERO control derive their voltages from a stable zener reference voltage.

4-3. CIRCUIT DESCRIPTIONS

A. POWER DISTRIBUTION

The ac power cord is connected directly to the circuit board assembly. Power is supplied to the primary windings of transformer T1 through the contacts of the POWER switch S1 and fuse F1. The fuse required for 115 Vac operation is 1.5 amp. For 230 Vac operation, an 0.75 amp fuse is required. Switch S4 connects the primary windings in parallel for 115 Vac use and in series for 230 Vac operation. The vacuum motor B1 and panel lamp DS1 are wired parallel to one of the primary coils. One secondary winding supplies 28 Vdc to the pen lift solenoid and sweep circuit through diode CR3 and capacitor C6. A shielded secondary winding for each axis supplies ±22 V through the rectifiers CR103, CR104, CR105, CR106, and filters C108, and C109. From the ±22 Vdc, resistors R140, R143 and zener diodes VR103, VR104 develop a regulated ±15 Vdc which is used by the integrated circuits U101, U102, and the X axis load circuit. Resistors R139, R142 and temperature compensated reference diodes VR101 and VR102 supply a ±9 Vdc reference voltage to the feedback potentiometer R137, the ZERO potentiometer R141, the I offset potentiometer R107, the V offset potentiometer R111, and the dual transistor Q102. The shielded secondary also supplies ±22 V through the rectifier formed by CR107, CR108, CR109, and CR110 to the power transistors Q105 and Q106. For the X axis this voltage is unfiltered, however for the Y and Y' axes capacitors C210, C211 and C310, C311 respectively are added to filter the voltage.

B. RANGE SWITCH

The RANGE switch controls the input and feedback attenuators and the selection for the SWEEP mode when that option is included.

C. INPUT ATTENUATOR

Section A of the RANGE switch S101 selects combinations of resistors R101, R102, R103, R104, and R105 to determine the input signal attenuation. Figure 4-2 shows in simplified form the combination used for each RANGE setting.

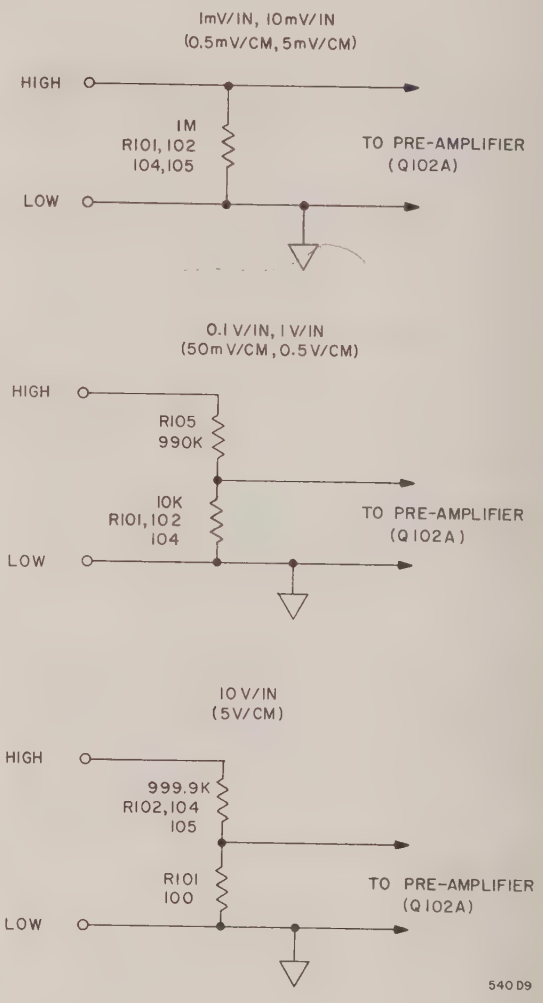


Figure 4-2. Input Attenuator (Simplified)

Table 4-1. RANGE and Pre-Amplifier Sensitivity

RANGE		ATTENUATION	PRE-AMP	
Volts Per Inch or Cm			Volts Per Inch or Cm	
ENGLISH	METRIC	RATIO	ENGLISH	METRIC
1 mV	0.5 mV	1:1 (Direct)	1 mV	0.5 mV
10 mV	5 mV	1:1 (Direct)	10 mV	5 mV
0.1 mV	50 mV	100:1	1 mV	0.5 mV
1 V	.5 V	100:1	10 mV	5 mV
10 V	5 V	10000:1	1 mV	0.5 mV

D. PRE-AMPLIFIER FEEDBACK ATTENUATOR

Section C of the RANGE switch S101 controls the pre-amplifier feedback attenuator which is comprised of resistors R116, R117, and R118.

Resistor R118 is used as a scaling resistor to adjust the pre-amplifier output to 500 mV for full scale deflection on all axes and for both English and Metric calibrated models. Figure 4-3 shows the attenuator circuit and lists specific R118 values.

The pre-amplifier feedback attenuator functions with the input attenuator to develop the five fixed pre-amplifier sensitivity ranges. Table 4-1 shows the input attenuation and pre-amplifier sensitivity for each range.

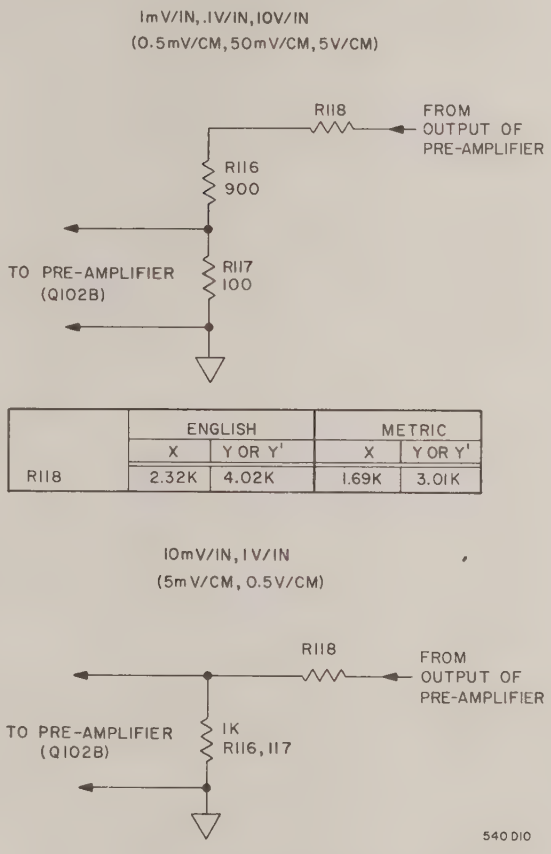
E. SWEEP CIRCUIT (540T and 540TM only)

When the optional sweep circuit is included in the recorder, the RANGE switch S101 controls the use of the circuit. In the SWEEP position, switch section A switches the pre-amplifier from the signal input HIGH to the output of the sweep circuit. Section B switches the pre-amplifier from the input LOW to the low side of the sweep circuit. Section D shifts control of the pen from the POWER switch S1 to the START/RESET switch S2.

The sweep circuit is shown in simplified form in Figure 4-4. Integrator capacitor C1 is charged through sweep rate resistors R6, R7, R8, R9, R10, R11, R12, and R13 as selected by SWEEP RATE switch S3. Increasing the selected resistance increases the RC time constant and slows the SWEEP RATE.

The operational integrator comprised of Q1, Q2, Q3, and Q4 shapes the charging curve of C1 into a linear ramp form.

Resistors R2, R3, and R5 form a voltage divider in parallel with zener regulator VR1 which provides a stabilized voltage to the operational



	ENGLISH		METRIC	
	X	Y OR Y'	X	Y OR Y'
R118	2.32K	4.02K	1.69K	3.01K

Figure 4-3. Feedback Attenuator (Simplified)

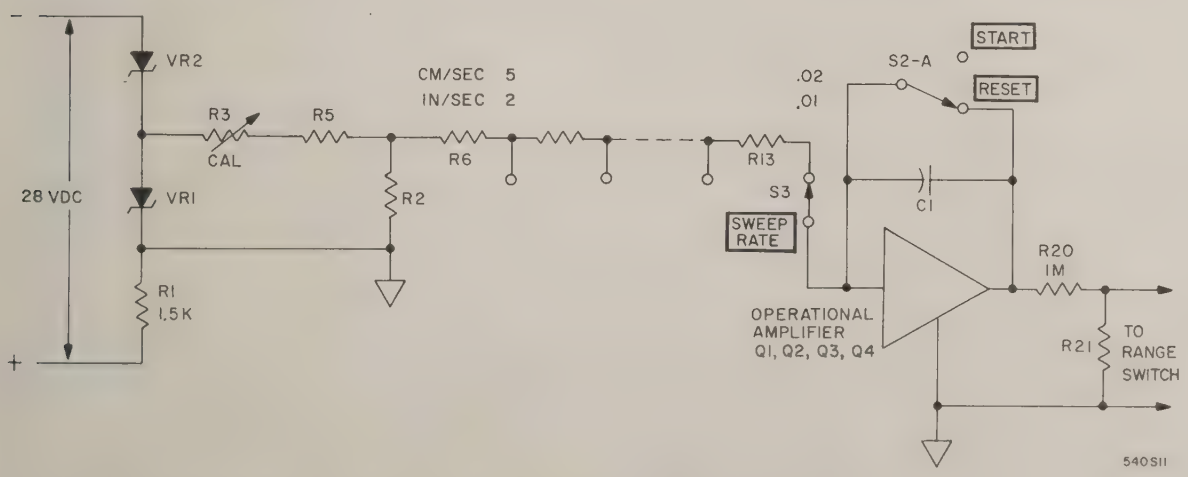


Figure 4-4. Sweep Circuit (Simplified)

integrator. Potentiometer R3 is adjustable for calibration of the sweep rate circuit.

Resistors R20 and R21 attenuate the output of the sweep circuit before it passes through the SWEEP position of the RANGE switch S101.

The RESET/START switch S2 controls both the sweep circuit and the pen lift solenoid K1 when the RANGE switch is in the SWEEP position and the POWER switch S1 is set to PEN. In the RESET position, the charging current is shunted around C1, and Q5 is biased to its "off" condition. K1 is de-energized lifting the pens. In the START position, the charging current is applied to C1 forming the sweep, and Q5 is biased to conduct. Current flows through K1 and the pens are lowered to the writing position.

F. PRE-AMPLIFIER

The pre-amplifier consists of dual transistor Q102, integrated amplifier U101, and the associated circuitry. Transistor Q102 operates as a differential comparator between the input voltage at TP101 and the pre-amplifier feedback voltage at TP102. Any voltage difference will appear amplified at the collector load resistors R112 and R113 and is applied to amplifier U101 for further amplification. The output at TP103 is fed back through the pre-amplifier feedback attenuator.

Resistors R109 and R110 form a voltage divider to reduce the voltage and power dissipation on Q102.

The I offset potentiometer R107 is used to remove any offset or differential between the base currents of Q101 and Q102A. The specific resistance value of R108 is determined at the factory by the actual functioning characteristics of the individual Q102 and Q101 transistors.

The V offset potentiometer R111 removes any offset or differential voltage between the input and feedback side of the pre-amplifier.

Diodes CR101 and CR102 provide overload protection for Q102. Resistor R114 and capacitor C102 form a network to frequency stabilize the loop gain.

G. FIXED/VARIABLE SWITCH AND VARIABLE CONTROL

The FIXED/VARIABLE switch S102 controls the connection between the pre-amplifier and the servo amplifier. In the FIXED position, the signal from U101 is routed directly through R121 to the input of the servo amplifier section, In the VARIABLE position, the signal is routed through the ten-turn VARIABLE potentiometer R119 for adjustable attenuation of the signal. Resistor R120 limits the maximum attenuation to approximately 10 to 1.

H. SERVO AMPLIFIER

The signal through S102 is filtered by the low pass combination of R122 and C104 and connected to the positive input of the integrated amplifier U102. This amplifier compares the conditioned signal and the servo feedback which is applied at the negative input of U102. The differential output of U102 is applied through switch S1 to the Class B power amplifier Q103, Q104, Q105, and Q106 which drives the servo motor B101.

Resistors R126 and R128 provide dissipation limiting for Q103 and Q104. R125 and R127 form the power amplifier local feedback. Resistors R124, R129, R130, R132, gain calibration potentiometer R131, and capacitor C105 make up the feedback around the servo amplifier and provide a low impedance drive at TP106 for the servo motor. Resistor R124 and capacitor C105 limit the bandwidth of the amplifier in order to reduce the response to possible noise on the signal.

I. SERVO MOTOR

The low inertia dc motor is driven by the output of the servo amplifier at TP106. The polarity and amplitude of the signal determines the direction and speed of motor rotation. Capacitor C112 on the motor reduces radio frequency interference.

J. FEEDBACK OR FOLLOW-UP POTENTIOMETER

The precision three turn follow-up potentiometer R137 is mechanically coupled to the servo motor, and uses the +9 V reference (see Paragraph 4-3. A.) to provide a voltage proportional to the pen position through the feedback attenuator to the inverting input of the amplifier U102.

Potentiometer R138 is used to calibrate the axis. R135 corrects for loading on the follow-up potentiometer. C107 and R136 form a low pass filter to remove high frequency noise from the follow-up potentiometer wiper arm.

K. ZERO CONTROL

The front panel ZERO control adjusts the offset potentiometer R141, which uses the ±9 V reference to provide a voltage through R144 to the summing point at TP104. This voltage is used to position the "zero" or "no input" pen position at any point on the recording area which effectively doubles the possible recording range on any axis.

L. FEEDBACK ATTENUATOR

The feedback attenuator R123 and R134 receives the signal from the follow-up potentiometer. The attenuation of the signal sets the basic axis sensitivity to produce a full scale deflection when a 500 mV signal is present at the input of U102.

R133 and C106 comprise a phase lead network which increases the bandwidth of the servo

system permitting a high gain setting of R131 increasing static accuracy.

M. PAPER LOAD CIRCUIT

Section A of the POWER switch S1 controls the operation of the paper load circuit. Switch sections S1B, S1C, and S1D control the connections between the integrated amplifier and the power amplifier stages of the servo amplifier in the X, Y and Y' axes respectively.

In the OPERate and PEN positions, sections S1B, S1C, and S1D couple the outputs of the integrated amplifiers directly to the power amplifiers for normal operation of the respective axes.

In the LOAD position, the output of the integrated amplifiers is disconnected for all axes. In the Y and Y' axes, the respective axis low is connected to the power amplifier.

In the X axis, a positive voltage is applied through switch section S1A capacitor C4, divider resistors R22 and R26, and switch section S1B to the power amplifier as shown in Figure 4-5. This voltage drives the carriage smoothly to the right extreme margin of the recording area to facilitate paper loading or notation.

In the OPERate and OFF positions, switch section S1A discharges C4 through R23 and CR1 to prepare the circuit for the next operation.

N. GUARD

The GUARD shield is used to minimize the effects of common mode voltages such as those encountered when measuring low level signals from thermocouples and strain gauges. Except for the sweep circuit, all of the circuits listed on the block diagram Figure 4-1 are shielded from the power ground due to their location within the GUARD.

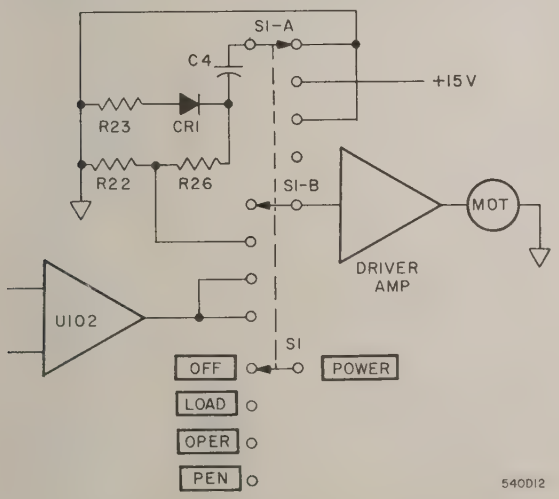


Figure 4-5. Paper Load Circuit

When the GUARD is connected to the signal source ground, i. e., when it is driven by the common mode generator, the effective capacitance from the input circuitry to ground is minimized. Thus, any common mode current and the recording error it might cause are greatly reduced.

O. RETRANSMITTING POTENTIOMETER OPTION

When the retransmitting potentiometer option is factory installed, only the mechanical hookup is accomplished. The requirements of the specific intended usage will determine the best means of connecting the required external reference voltage (±100 Vdc, maximum) into the potentiometers and the retransmitted position signal out to the accessory equipment. The remote connector J1 has available pin connections which may be used if direct wiring to the potentiometers is not suitable.

Field installation of this option may be accomplished by replacing the standard follow-up potentiometers with the required dual units according to the instructions in Paragraph 5-3. E. 1. See Section 6 for the specifications and part number of the dual potentiometers used for this option.

P. POTENTIOMETRIC INPUT OPTION

The potentiometric option uses the E wafer of the RANGE switch S101 to disconnect the input attenuator for the two most sensitive settings of the RANGE switch. This passes the input signal directly to the pre-amplifier for these two RANGE settings and provides an input resistance of 50 Megohms, typical.

The potentiometric option may be disabled in the field by installing jumper W101 between resistors R105 and R106 as shown on the schematic.

4-4. MECHANICAL DRIVE

The mechanical drive assembly for each axis consists of a servo motor, a slip clutch, a cable sheave, pulley system, and drive cables.

The X axis drive controls the carriage position through a single cable secured at both ends of the carriage.

The Y and Y' axes systems each use two cables to position the pen assemblies along the carriage. Each pair of cables form a two loop system around the pulleys on its respective pen slider assembly. This system permits the carriage to move along the X axis without changing the position of the pens with respect to the Y and Y' axes.

SECTION 5
MAINTENANCE

5-1. GENERAL

This section contains both preventive and corrective maintenance procedures. Preventive maintenance includes cleaning, lubrication, performance checks and mechanical adjustments. Corrective maintenance covers troubleshooting, calibration procedures, and parts replacement.

5-2. PREVENTIVE MAINTENANCE

Cleaning and adjustment of cable and drive system should be performed about every six months. Since the principal moving parts of the recorder are fitted with sealed ball bearings, no lubrication of the mechanical system is required. However, dirt and dust should be prevented from entering the bearings. The vacuum fan motor, which also drives the cooling fan, should be lubricated with light machine oil about twice a year.

A. PERIODIC MAINTENANCE PROCEDURE

The following cleaning, adjustment, and lubrication procedure is recommended every six months.

1. Remove all signal and power connections to the recorder.

2. Remove the six screws which hold the bottom cover, and remove the bottom cover.

3. Place the recorder in its optional maintenance stand as shown in Figure 5-1.

4. Release the circuit board by removing six screws, two on each outside edge and two along the top. Rotate the circuit board out.

5. Clean the recorder with low pressure air.

6. Check all electrical connectors and mechanical connections. Ensure that all screws, nuts, and bolts are tight.

7. Check for any binding or restriction of travel of the pen slider and carriage. The tension of the cables should be great enough to prevent the cables from slipping off the pulleys, but not so tight as to cause excessive friction or binding. The cable tension of the horizontal or carriage axis can be adjusted by first loosening the hold-down screws on the sheave then retracting or extending the cable. A tension device on the horizontal axis automatically adjusts for expansion or contraction of the table due to variations in temperature.

CAUTION

Do not lubricate pulleys, bearings, cables, or the gearing of the servo drives.

8. Lubricate the vacuum fan motor twice a year by placing one drop of light machine oil on each of two felt pads adjacent to the bearings. Wipe off any excess oil.

9. Clean the recorder bed with a damp cloth. The carriage bearings and the edge of the bed on which the carriage runs should be kept clean or high friction points may result.

B. CHECKOUT PROCEDURE

1. Mechanical Performance Checks: The recorder should meet all the mechanical requirements presented in this section. If it fails to meet any requirement, it should be adjusted as specified. Should an electrical malfunction be encountered during the mechanical checks, locate and repair the problem before proceeding. In some cases, a review of the electrical checks might be helpful in pin-pointing malfunctions discovered during the mechanical checks.

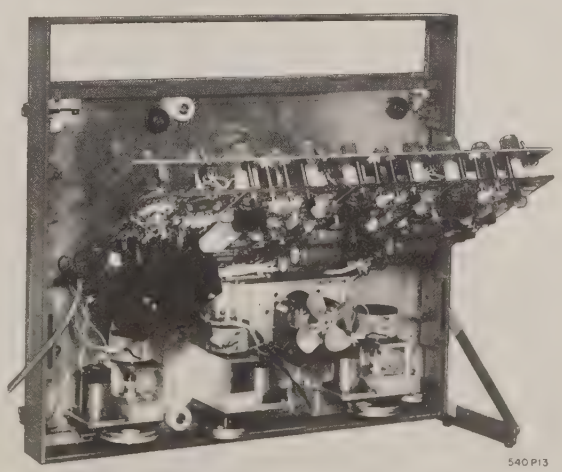


Figure 5-1. Model 540 X-Y-Y' Recorder Opened for Maintenance

Note

Perform Steps a., and d., with the pen assemblies removed.

a. Paper Hold-down Force and Vacuum System

Align a sheet of 11 x 16-1/2 inch graph paper on the plotting surface; set the POWER switch to OPERate. Check the force required to move the paper in a plane parallel to the plotting surface.

This force should be at least 7 ounces for 11 x 16-1/2 inch graph paper and 2.5 ounces for 8-1/2 x 11 inch graph paper. Failure to obtain an adequate holding force could be caused by misalignment of the graph paper, restricted vacuum holes, or misalignment of the vacuum fan. Failure to obtain any holding force would be caused by an inoperative vacuum motor.

Ensure that the vacuum holes on the plotting surface are open and free from dust, bits of paper, etc. If necessary realign the vacuum fan by loosening the appropriate screws and either moving the motor with respect to the recorder frame, or repositioning the vacuum fan along the motor drive shaft. If the vacuum motor is inoperative, check for an open power lead to the motor or an open winding in motor.

b. Pen Lift Operation

Use a clean sheet of 11 x 16-1/2 inch graph paper to check the pen lift operation. Set the POWER switch to OPERate. Use the ZERO controls to move the pens around the edges and through the center of the graph paper. The pen tips must clear the paper by 0.030 inches (0.075 cm) at all points.

Check the pen-down position by setting the POWER switch to PEN. Move the pens around the edges and through the center of the graph paper. Make certain that both pens write everywhere on the paper.

Check the pen-lift action. The pen-lift bar and the pen assemblies must snap up when the POWER switch is moved from PEN to OPERate and they must snap down when the switch is moved from OPERate to PEN.

c. Pen Spring Tension

With the POWER switch set to PEN, check the force holding the pens on the graph paper. This force should be between 1/4 and 1/2 ounces (or 8 to 12 grams).

d. Paper Alignment

Ensure that the graph paper is properly aligned on the recording surface according to Paragraph 3-3.C. Set the POWER switch to PEN. Use the X axis ZERO control to draw straight horizontal lines with both pens. Use the Y and Y' ZERO controls to draw straight vertical lines. If the horizontal and vertical lines are not perpendicular to each other and parallel to the corresponding lines on the graph paper, the horizontal cable may not be properly attached to the carriage. See Paragraph 5-3.E.2.d.

e. Recording Area

Set the POWER switch to PEN. Use the ZERO controls to check that the pens write beyond all four margins of the graph paper. If the pens fail to write beyond the left and right margins, the horizontal axis cable may not be properly installed. See Paragraph 5-3.E.2.d. If the pens fail to write beyond the top and bottom margins, the vertical axes cables may not be properly installed. See Paragraphs 5-3.E.2.b. and 5-3.E.2.c.

Note

Insure that pen or cartridge travel is not limited by the mechanical stops in the follow-up potentiometer. See Paragraph 5-3.C.1.m.

2. Electrical Performance Checks:

Align a sheet of 11 x 16-1/2 inch graph paper on the plotting surface. See Table 5-1 for a list of the required test equipment. Perform calibration according to Paragraph 5-3.D. if the recorder fails any of the following checks.

a. Dead Band

Turn the POWER switch to PEN. Check the X axis dead band by manually moving the carriage off the null position and allowing it to slowly return to null. Do this for both the positive and negative directions using the Y and Y' ZERO controls to prevent overlapping. The dead band should not exceed 0.030 inches.

Repeat the procedure for the Y and Y' axes by moving the pens off null. The dead band for each axis should not exceed 0.020 inches.

b. Retrace Hysteresis

Set the RANGE switch to 100 mV/IN (50 mV/CM), the FIXED/VARIABLE switches to FIXED, and the POWER switch to OPERate. Adjust the input signal generator to give a linear (triangular wave) output equal to a writing speed of 2 inches per second on all axes. Turn the POWER

switch to PEN. Draw a trace and retrace, then return the POWER switch to OPERate. The maximum allowable deviation between the trace and the retrace is 0.030 inches (0.075 cm). Establish a 10 to 1 slope by setting the X axis RANGE switch to 1 V/IN (0.5 V/CM). Draw a trace and retrace; the deviation should not exceed 0.030 inches. Return the X axis RANGE switch to 100 mV/IN (50 mV/CM), and set the Y and Y' RANGE switches to 1 V/IN (0.5 V/CM) to establish a 1 to 10 slope. The trace, retrace deviation should not exceed 0.020 inches (0.050 cm).

c. Overshoot

Set the X axis RANGE switch to 1 V/IN (0.5 V/CM) and the FIXED/VARIABLE switch to FIXED. Connect a dc source through an on-of switch to the X axis input as shown in Figure 5-2. Set the on-off switch to off and adjust the dc source for an output of approximately 8 volts. Set the source switch to on. The pen should plot a horizontal line about 8 inches long, overshoot, and return to the 8 inch point. Repeat this procedure one or two times adjusting the Y or Y' ZERO control to prevent overlapping. The overshoot should not exceed 0.30 inches (0.75 cm).

Move the dc source and switch setup to the Y axis and repeat the test. Repeat the test again for the Y' axis. The overshoot for the Y and Y' axes should not exceed 0.20 inches (0.50 cm).

d. Frequency Response

Set the X axis RANGE switch to 1 V/IN (0.5 V/CM) and the FIXED/VARIABLE switch to FIXED. Adjust the function generator for a 1 Hz sinewave output of 1 volt peak-to-peak, and apply the signal to the X axis input. If the sweep circuit is included in your recorder, use the SWEEP setting on the Y axis RANGE switch and set the SWEEP RATE switch to 0.2 IN/SEC. If your recorder does not have the sweep circuit, manually rotate the Y axis ZERO control during the following step. Turn the POWER switch to PEN and set the RESET/START switch to START. Initially the horizontal deflection will be 1 inch (2 cm). Slowly increase the generator frequency to 5 Hz keeping the amplitude constant. At 5 Hz the deflection should be at least 0.7 inches (1.4 cm).

Repeat this check for each of the Y and Y' axes.

e. Variable Sensitivity

Set the RANGE switches to 1 V/IN (0.5 V/CM) and the FIXED/VARIABLE switches to FIXED. Turn the POWER switch to PEN and establish a "zero" position. Apply a 2 volt dc signal to all three axes. There should be a 2 inch (4 cm) deflection of each axis. Set the FIXED/VARIABLE switches to VARIABLE with the VARIABLE potentiometer controls to the full clockwise positions. The deflection should be at least 2 inches. Turn the VARIABLE potentiometer controls to their full counter-clockwise positions. The deflections should decrease to no more than 0.2 inches (0.4 cm) with reference to the established "zero" position. Return the FIXED/VARIABLE switches to FIXED.

f. Common Mode Rejection

Connect a sinewave generator and a 1 K resistor to the X axis inputs as shown in Figure 5-3. Set the X axis RANGE switch to 1 mV/IN (0.5 mV/CM) and the FIXED/VARIABLE switches to FIXED. Adjust the generator for a 30 volt peak-to-peak output at a frequency within ±2 Hz of the power line frequency. Use the Y or Y' axes in the sweep mode at a SWEEP RATE of 0.2 IN/SEC (0.5 CM/SEC), or manually rotate the Y or Y' ZERO control during the following step. Turn the POWER switch to PEN. The horizontal deflection should be not more than 0.10 inches (0.25 cm).

Move the generator setup to the Y and Y' axes and perform the test for each axis in turn.

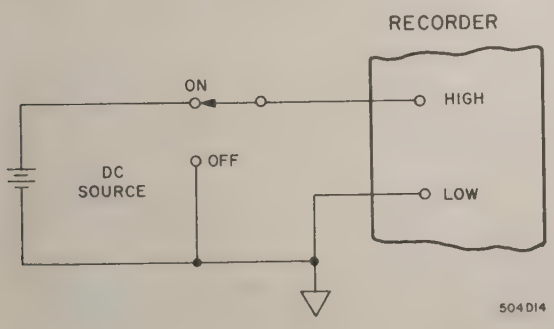


Figure 5-2. Setup for Overshoot Check

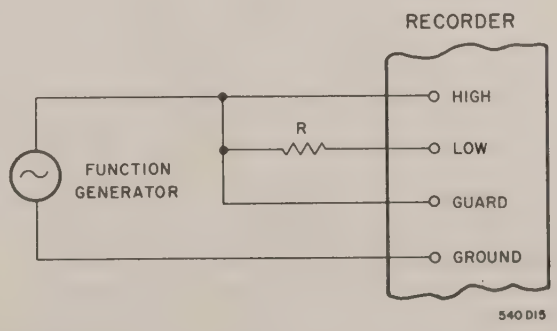


Figure 5-3. Setup for Common Mode Rejection Check

g. Paper Load Operation

Set the POWER switch to OPERate. Use the X axis ZERO control to establish a carriage "zero" position at the left margin of the recording area. Turn the POWER switch to LOAD. The carriage should move smoothly to the right margin of the recording area. Return the POWER switch to OPERate. The carriage should return to the established "zero" position.

5-3. CORRECTIVE MAINTENANCE

A. GENERAL

The recorder should meet all mechanical and electrical requirements outlined in Paragraph 5-2. B. If the recorder fails any of the mechanical requirements, it should be adjusted or repaired to specification. If the recorder fails to meet the electrical requirements, refer to the trouble analysis guide, Table 5-2. The following table lists the test equipment required for checkout and calibration of the recorder.

Table 5-1. Test Equipment

1. Spring scale with 1/4 ounce resolution from 0 to 16 ounces.
2. Variable dc source 0 to 10 volts.
3. Voltmeter with 1 millivolt resolution. (The voltmeter is used to supplement the variable dc source.)
4. Low frequency function generator with frequency range 0.01 to 100 Hz, and 0 to 30 volts peak-to-peak output (Hewlett-Packard Model 202A or equivalent).
5. Oscilloscope (Tektronix Model 502 or equivalent).
6. 200 Ω pen solenoid or a 200 Ω, 5 W resistor.

B. TROUBLE ANALYSIS

A list of possible troubles, their probable causes, and suggested remedies is provided in Table 5-2. More extensive problems can be analyzed with the aid of the schematic in Figure 6-11 and the Principles of Operation, Section 4. Prior to using the troubleshooting guide, set the POWER switch to OPERate and check the power supply voltages with a voltmeter, refer to Table 5-3.

C. CIRCUIT BOARD VOLTAGE CHECKS

The following paragraphs describe the procedures necessary to power and signal voltages throughout the recorder. In the event of an electrical malfunction, these procedures should be consulted to isolate the malfunction.

1. Preliminary Procedures: Visually inspect circuit board for solder shorts, damaged or missing components, etc. Check switches for proper mechanical operation.

Check that the 115/230 switch and the fuse agree with the ac power source being used. Plug in the power cord and turn the POWER switch to OPERate; the panel lamp should light.

For the following procedures the servo motor and feedback potentiometer are not part of the tests, at least the high side of the motor and the wiper of the potentiometer must be disconnected from the circuit board for each axis.

2. X Axis:

a. Power and Reference Supply

Set the RANGE switch to 10 V/IN (5 V/CM), the FIXED/VARIABLE switch to FIXED, and the RESET/START switch to RESET.

Use the voltmeter for dc voltage measurements and the oscilloscope for ripple measurements. The X axis common TP113 is the reference point. The test points TP or voltage locations are indicated on the circuit board. (Table 5-3.)

b. Servo Amplifier

CAUTION

Shorting of the servo amplifier output TP106 to common or to the supply voltages may destroy the power transistors.

Turn VARIABLE control fully ccw and short the arm to axis common. Set gain control R131 to mid-point.

Set oscilloscope to dc input. 5 volts/cm Vertical, 2 mv/cm Horizontal, and zero the trace on the center of the screen. Turn the ZERO control and observe that the output of the amplifier at TP106 can "null" or "zero." The amplifier output should be able to swing plus (cw) or minus (ccw) by means of the ZERO control. This "off null" signal should take the form of a plus or minus full wave rectified voltage with a peak value of approximately 22 volts.

Table 5-2. Troubleshooting Guide

SYMPTOM	PROBABLE CAUSE	SUGGESTED REMEDY
1. Sluggish response to input signals; little resistance to pen or carriage movement; excessive overshoot.	a. Gain setting too low. b. Axis cables loose. c. Loose clutch.	a. Increase gain setting. b. Restring cables vertical axes, Paragraph 5-3. D. 2. b. & c.; horizontal axis, Paragraph 5-3. D. 2. d. c. Tighten clutch.
2. Pen or carriage oscillates; excessive jitter.	a. Gain setting too high. b. Excessive common mode signal. c. Instrument ungrounded.	a. Reduce gain setting. b. Reduce common mode signal. c. Ground instrument. See Paragraph 2-3.
3. Pen does not lower to paper.	a. Improper conditioning of control panel or remote switches. b. Defect in the mechanical linkage between pen solenoid and pen. c. Defective pen solenoid, or circuit.	a. Review operation procedures in Section 3 and condition recorder accordingly. b. Check linkage for dirt or mechanical binding, clean and repair linkage as required. c. Replace solenoid, or repair circuit.
4. Pen will not write.	Exhausted ink supply	Replace marker
5. Pen skipping.	a. Writing speed too fast.	a. Reduce writing speed.
6. Trace is erratic in one or more positions. Positions do not change with ZERO adjustment.	a. Follow-up potentiometer defective. b. High friction points.	a. Replace potentiometer. b. Clean bearing and bearing rods. Eliminate any mechanical binding.
7. Pronounced deviation in trace; not erratic.	a. Excessive friction. b. Excessive cable tension.	a. Clean bearing and bearing rods. Eliminate any mechanical binding. b. Loosen cables.
8. Servo drives to one end of travel as input signal (less than full scale) is applied.	Loss of feedback voltage: a. Follow-up pot open. b. Open circuit at some point between follow-up pot arm and input to servo amplifier.	a. Replace pot if open is indicated. b. Restore continuity, replace any open component.
NOTES (1) This symptom can also be caused by a phase reversal, due to improper replacement of a faulty component; e.g., motor leads or follow-up pot leads. (2) In normal operation, a servo can drive to the margins if the input is left open and the RANGE switch in either of the two most sensitive settings. See the NOTE in Paragraph 3-4. A. 3.		
9. Servo inoperative or drives continuously in one direction.	a. Servo motor defective. b. Faulty component in servo amplifier circuitry (see Figure 4-5).	a. Replace. b. Locate by checking dc levels and by applying identical signals through all servo amplifiers and comparing oscilloscope traces; replace faulty components.
10. Servo OK but no response or faulty response from the input terminals.	Defect in the input attenuator, pre-amplifier, or pre-amplifier feedback attenuator.	Locate by checking dc levels and by tracing signals through input attenuator and pre-amplifier. Replace defective components.

Table 5-3. Power and Reference Voltage Measurements

SUPPLY	DC VOLTAGE[1]			LINE RIPPLE[1] VOLTAGE Peak-to-Peak	
	MIN	TYP	MAX	TYP	MAX
+22 V, C110	Unfiltered[2]			+22 V	+26 V
-22 V, C111	Unfiltered[2]			-22 V	-26 V
+22 V, TP109	20	22	25	1.2 V	2 V
-22 V, TP112	-20	-22	-25	1.2 V	2 V
+15 V, TP108	14	15	16	20 mV	60 mV
-15 V, TP111	-14	-15	-16	20 mV	60 mV
+9 V, TP107	8.5	9	9.5	0.5 mV	2 mV[3]
-9 V, TP111	-8.5	-9	-9.5	0.5 mV	2 mV[3]

NOTES:
1. Voltages are based on a nominal line voltage 115/230, 60 Hz.
2. Y and Y' axes have a filtered voltage, ±22 Vdc. Using the ZERO control, it should be possible to make the ripple less than 100 mV, P-P.
3. The ripple on the ±9 V will be accompanied by approximately 1 mV P-P of high frequency noise.

Note

The Y and Y' "off null" signals will be plus or minus a dc level up to 22 volts.

Remove the short.

c. Pre-Amplifier

Observe the output TP103 of the amplifier on a dc coupled scope. Adjust V offset potentiometer R111 so that the change in dc level between the 1 V/IN (0.5 V/CM) and the 100 mV/IN (50 mV/CM) ranges is less that 500 μV.

Set RANGE switch to 10 mV/IN (5 mV/CM). Adjust I offset potentiometer so that there is less than 2 mV change in the dc level when switching from a short to an open at the input terminals HIGH and LOW. If necessary, R108 may be reduced to as low as 220 K.

Recheck V offset and I offset adjustments for interaction.

Set the RANGE switch to 0.1 V/IN (50 mV/CM) and apply +9 Vdc TP107 to the HIGH terminal. The output at TP103 should be approximately 3 Vdc ±10% (2.4 Vdc). Change the RANGE switch to 1 V/IN (0.5 V/CM); the voltage should decrease by a factor of ten.

Note

The Y and Y' axes should give 4.5 Vdc (3.6 Vdc, metric).

Remove the +9 Vdc.

3. Y and Y' Axes: Perform the checks of Paragraph 5-3.C.2. on the Y and Y' axes.

4. Pen Solenoid Voltage Supply: Connect a 200 Ω pen solenoid or 200 Ω, 5 W resistor to circuit board at points numbered 32 and 33 on the board.

Set all RANGE switches to 10 V/IN (5 V/CM). Set the POWER switch to PEN, the solenoid should energize. Turn POWER switch to OPERate, the solenoid should de-energize.

5. Sweep Circuit (540T and 540TM only): Set the X axis RANGE switch to SWEEP, the RESET/START switch to RESET, and the SWEEP RATE switch to 1 IN/SEC (2 CM/SEC). Observe the voltage at TP4 referenced to TP3 on a dc coupled scope. Set the RESET/START switch to START. The slope should be approximately 10 mV/sec (12 mV/sec) and the voltage change should be at least 150 mV (187 mV). With RANGE switch set to SWEEP, determine that the sweep signal

appears at each axis; X axis, TP101 to TP113; Y axis, TP201 to TP213; Y' axis, TP301 to TP313.

Table 5-4. Pen Solenoid and Sweep Circuit Voltage Checks

TEST POINTS	DC VOLTAGE			LINE RIPPLE VOLTAGE Peak-to-Peak	
	MIN	TYP	MAX	TYP	MAX
TP2 to TP1	25	28	31	2 V	3 V
TP3 to TP1	12.5	15.6	18.5	2 V	3 V
TP2 to TP3	11.7	12.4	13.1	6 mV	30 mV
TP5 to TP3	5.3	5.6	5.9	4 mV	20 mV

NOTES:

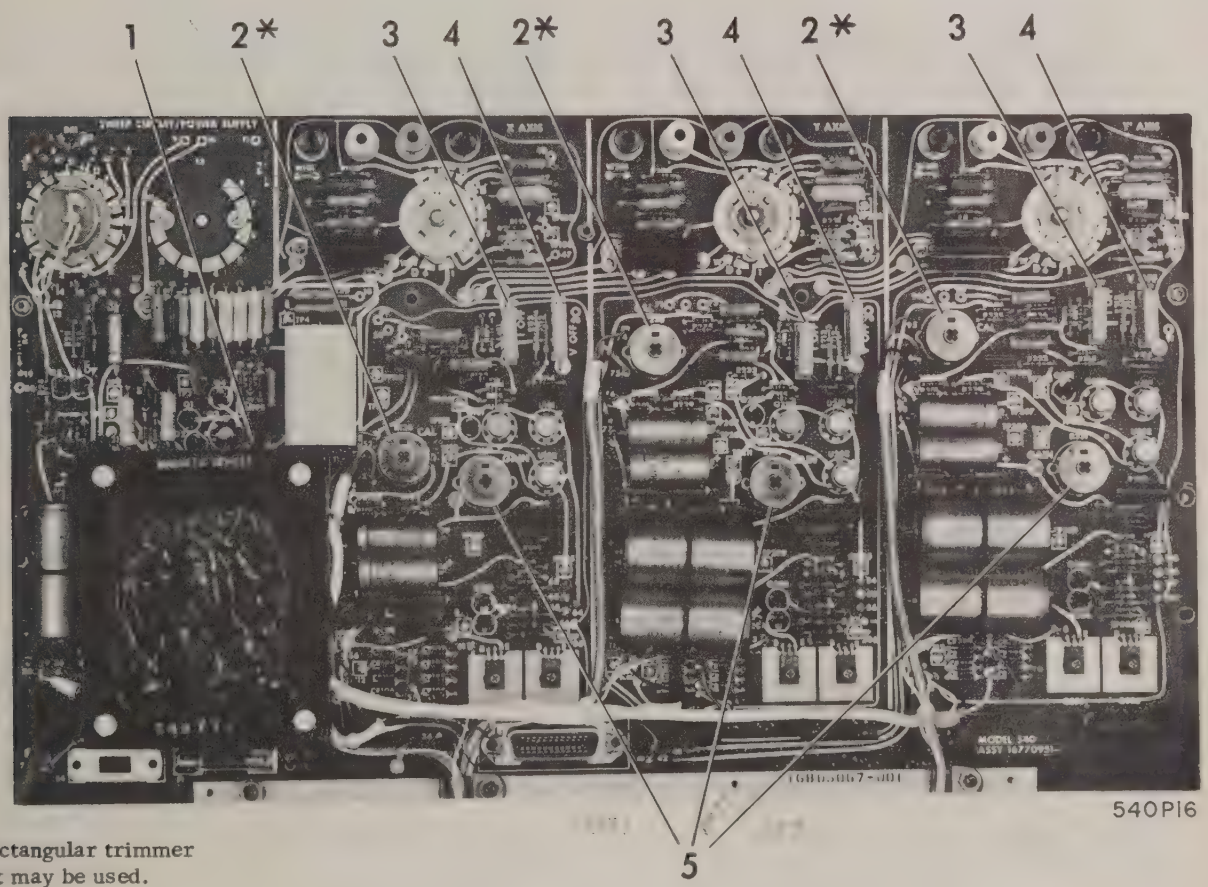
1. Voltages are for 115 Vac, 60 Hz.
2. POWER switch must be in the PEN position for voltage checks.

D. CALIBRATION

Calibration of the recorder involves the adjustment of twelve potentiometers (thirteen for models 540T and 540TM). The calibrate potentiometers are adjusted to give proper deflection sensitivity for the X, Y, and Y' axes. The sweep calibrate potentiometer is adjusted to establish the proper inch per second (cm per second) rates. All potentiometers are accessible when the bottom cover is removed. Locations are shown in Figure 5-4.

1. Preliminary Checks and Adjustments:

a. Gain Potentiometers



* Rectangular trimmer pot may be used.

1. Sweep Calibration Potentiometer
2. Axis Calibration Potentiometers
3. I Offset Potentiometers
4. V Offset Potentiometers
5. Servo Gain Potentiometers

Figure 5-4. Calibration Adjustment Locations

The X, Y, and Y' axes gain potentiometers must be adjusted to meet the requirement of Paragraph 5-2. B. 2. a. If the dead band is excessive, increase the axis gain potentiometer R131, R231, or R331. The axis gain must not be high enough to produce oscillations or rough traces.

b. Voltage and Current Offsets

1) Set the POWER switch to OPERate.

2) Adjust the X axis voltage offset potentiometer R111 so there is less than 0. 010 inch (0. 025 cm) static carriage deflection when switching between 1 V/IN (0. 5 V/CM) and 100 mV/IN (50 mV/CM) on the RANGE switch.

3) Set the X axis RANGE switch to 10 mV/IN (5 mV/CM). Adjust the current offset potentiometer R107 so there is less than 0. 050 inch (0. 125 cm) static carriage deflection between an open and a short at the input HIGH and LOW terminals. For the potentiometric option, use 1 meg instead of an open.

Note

If the adjustment does not come in and the wiper of R107 is at the maximum voltage, R108 may be reduced as low as 220 K.

4) Cycle Steps 2) and 3) until there is no detectable interaction.

5) Perform Steps 1) through 4) on the Y and Y' axes using the appropriate Y and Y' axes controls.

2. Record Mode Calibration:

Note

All preliminary adjustments in Paragraph 5-3. D. 1 must be performed prior to acutal dc calibration.

a. On the X axis set the FIXED/VARIABLE switch to FIXED and the RANGE switch to 100 mV/IN (50 mV/CM).

b. Turn the POWER switch to PEN and establish a "zero" reference point using the X axis ZERO control. Apply 1. 5 ±0. 00075 Vdc to the X axis input terminals.

c. Adjust the X axis calibration potentiometer R138, see Figure 5-4, for exactly 15 inches (30 cm) deflection.

Note

Adjustment of the axis calibration potentiometer moves the "zero" setting.

d. Cycle Steps b. and c. until the potentiometer adjustment produces a negligible shift in the "zero" point.

e. Reduce the voltage in 0. 1 steps to give 1 inch (2 cm) steps on the graph. Using the Y and Y' ZERO controls, determine that each step is within ±0. 015 inch (0. 038 cm).

f. Check the deflection sensitivity on all other X axis ranges.

g. Set the Y and Y' axes FIXED/VARIABLE switches to FIXED and the RANGE switches to 100 mV/IN (50 mV/CM).

h. Establish "zero" reference points using the Y and Y' axes ZERO controls. Apply 1 ±0. 0005 Vdc to the Y and Y' axes input terminals.

i. Adjust the Y and Y' axes calibration potentiometers R238, R338, see Figure 5-4, for exactly 10 inches (20 cm) deflection.

j. Cycle Steps h. and i. until adjustment of the potentiometers produces negligible shifts in the "zero" reference points.

k. Reduce the voltage in 0. 1 volt steps to give 1 inch (2 cm) steps on the graph. Using the X axis ZERO control determine that each step is within ±0. 010 inch (0. 025 cm).

l. Check the deflection sensitivity on all other Y and Y' ranges.

3. Sweep Mode Calibration Procedure (Model 540T and 540TM):

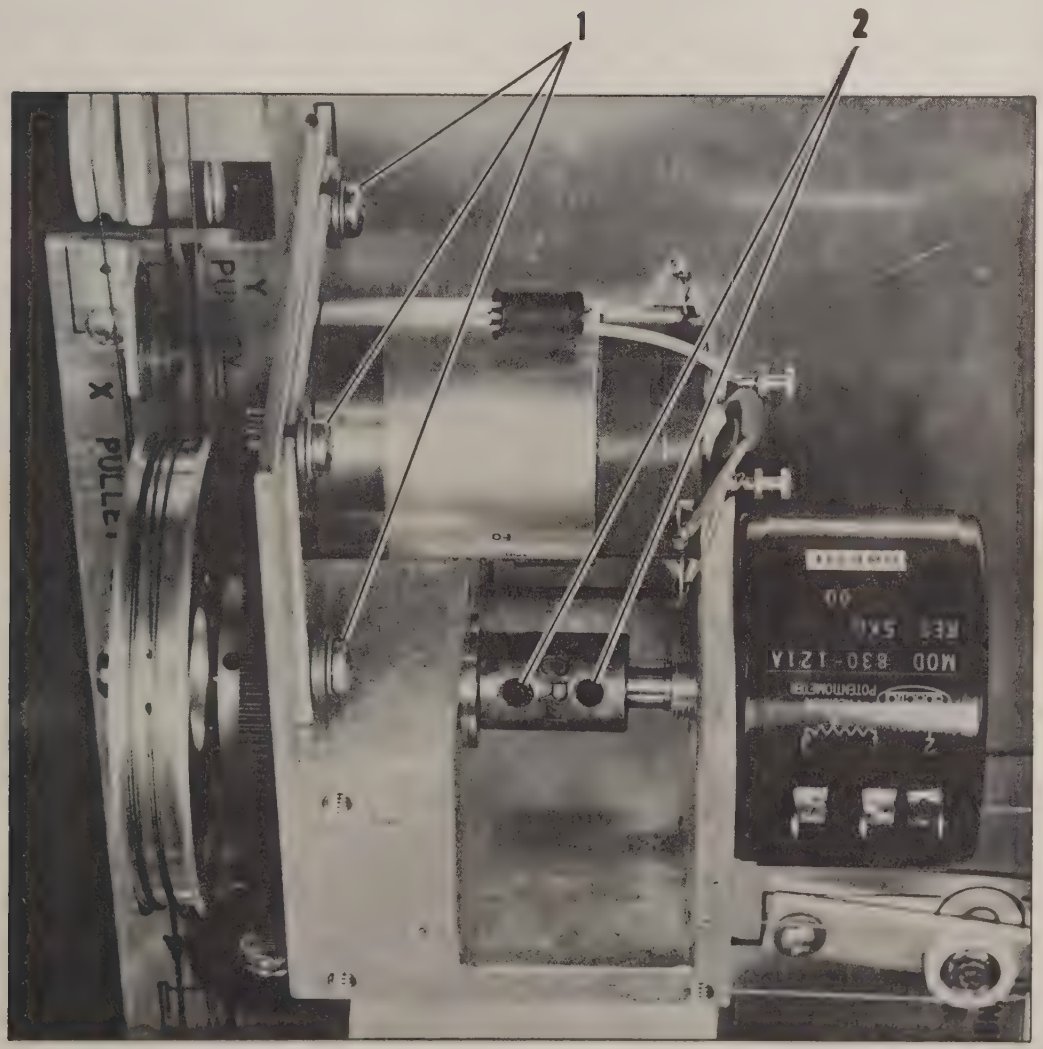
Note

Each axis must be calibrated according to Paragraph 5-3. D. 2. prior to calibration of the sweep circuit.

a. Set the X axis RANGE switch to SWEEP, the RESET/START switch to RESET, the POWER switch to PEN, the SWEEP RATE switch to 0. 5 IN/SEC (1 CM/SEC) and the FIXED/VARIABLE switch to FIXED.

b. Using the X axis ZERO control, position the pen to the left edge of the graph.

c. Apply a signal with a known time interval to the Y or Y' axis.



540PI7A

1. Motor Mount Screws (4, one behind motor)
2. Coupling Set Screws

Figure 5-5. Mechanical Drive Assembly

d. Set the RESET/START switch to START.

e. After at least 10 inches (25 cm) of travel return the switch to RESET.

f. Observe the sweep rate, then adjust the calibration potentiometer R3 (see Figure 5-4) to bring the rate error within ±1% of full scale.

g. Check all the other SWEEP RATE settings for ±1% calibration.

E. PARTS REPLACEMENT

1. Follow-up Potentiometer Replacement: After long periods of service the follow-up potentiometers may wear and become noisy. The replacement procedure (see Figure 5-5) for the potentiometer is outlined below:

a. Remove all signal and power connections from the recorder.

b. Mount the recorder in the maintenance stand, refer to Paragraph 5-2. A. 1-4.

c. Manually position the pen trolley bracket to the lower right corner of the plotting surface. This rotates both follow-up potentiometers counter-clockwise.

d. Remove the bottom cover.

e. Loosen the two set screws on the potentiometer shaft coupling.

f. Deleted

g. Pull the potentiometer until the shaft is free.

CAUTION

Cover the recorder with a cloth or other protective material to prevent solder from dropping into the recorder.

h. Unsolder all electrical connections noting the color coding.

i. Solder the electrical connections to the new potentiometer.

j. Slide the new potentiometer through the bracket. Seat the shaft in the coupling.

k. Ensure that the potentiometer alignment pin is positioned in its bracket hole. There should be a slight clearance (0. 010-0. 020) between potentiometer front and the rear face of the bracket.

l. Turn the potentiometer shaft full counter-clockwise then back off 5 or 10 degrees.

m. Ensure that the sheave is still in the full counter-clockwise position.

n. Tighten the two set screws on the coupling.

o. Manually move the carriage to the maximum extent of travel. If any binding or restriction of full travel occurs, loosen the set screws and check Steps l. and n. Ensure that full travel of the carriage is not limited by the stops within the potentiometer.

p. Recalibrate the recorder, Paragraph 5-3. D. 3.

2. Cable Installation:

a. Two cables are used to move each pen slider bracket along the vertical axis; one cable is used to move the carriage along the horizontal axis. The cables should be routed according to the arrows and the alphabetical designations shown in Figures 5-6 for the Y axis, and 5-7 for the Y' axis, and Figure 5-8 for the horizontal X axis. All directions - clockwise, counter-clockwise, upper and lower - are given from the viewpoint of the accompanying illustrations. Prepare the recorder as follows:

1) Remove all signal and power connections.

2) Mount the recorder in the maintenance stand.

3) Remove the pen assemblies.

4) Remove the bottom cover.

5) Remove the bezel by removing four hold-down screws.

6) Remove carriage cover by firmly pushing

the cover toward front panel compressing hinge spring. Slide carriage cover off hinge pin.

7) Remove the six hold-down screws from the circuit board, rotate out to its restraining strap.

b. Y Axis Cables

1) See Figure 5-6. Rotate the Y sheave counter-clockwise to its stop.

2) Move the pen slider to the lower end of the carriage. Insert a holding pin (4-40 x 3/8 stud or screw will suffice) through hole R in the pen slider and hole A in the carriage. This prevents the pen slider from moving along the carriage while the cable is being strung.

3) Thread the cable through hole B and secure under screw C.

4) Wrap the cable clockwise around the sheave to pulley D. Then string cable past pulleys E, F, G, H, I, and thread in hole in bracket insert.

5) Rotate the sheave counter-clockwise to its stop, winding the cable onto the sheave.

6) Secure the cable by tightening screw J at this point.

7) Insert the second cable into L and secure under the remaining sheave screw.

8) Wrap the cable counter-clockwise around the sheave to pulley M. Then string the cable past pulleys N, O, P, and secure under clamp Q.

9) Remove the holding pin from the pen slider.

10) Check the tension on both Y cables and adjust according to Paragraph 5-2. A. 7.

c. Y' Axis Cables

1) See Figure 5-7. Rotate the Y' sheave clockwise to its stop.

2) Move the pen slider to the lower end of the carriage. Insert a holding pin (4-40 x 3/8 stud or screw will suffice) through hole R in the pen slider and hole A in the carriage. This prevents the pen slider from moving along the carriage while the cable is being strung.

3) Thread the cable through hole B and secure under screw C.

4) Wrap the cable clockwise around the sheave to pulley D. Then string cable past pulleys E, F, G, H, I, and J, and thread in hole in bracket insert.

5) Rotate the sheave counter-clockwise to its stop, winding the cable onto the sheave.

6) Secure the cable by tightening screw L at this point.

7) Insert the second cable into hole M and secure under the remaining sheave screw.

8) Wrap the cable counter-clockwise around the sheave to pulley N. Then string the cable past pulleys P, Q, T, and secure under clamp U.

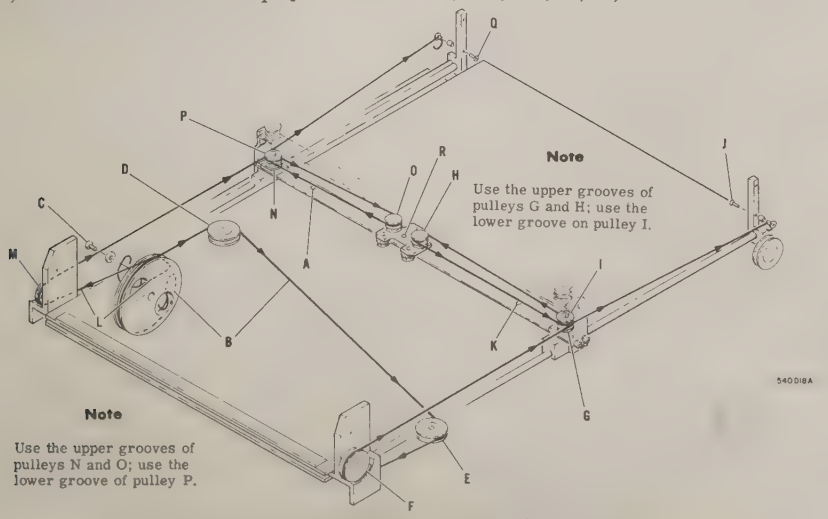


Figure 5-6. Installation of the Y Axis Cables

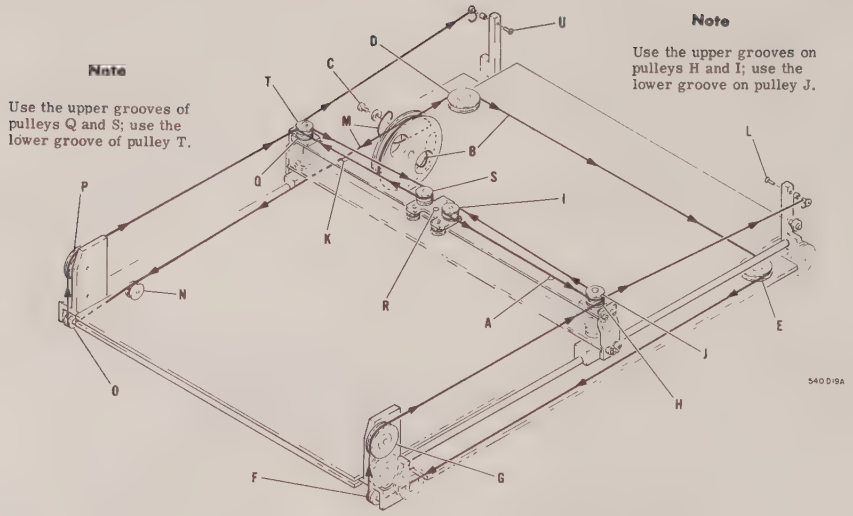


Figure 5-7. Installation of the Y' Axis Cables

9) Remove the holding pin from the pen slider.

10) Check the tension on both Y' cables and adjust according to Paragraph 5-2. A. 7.

d. X Axis Cable

1) See Figure 5-8. Turn the X sheave counter-clockwise to its stop.

2) Insert the cable end through hole A and secure under screw B.

3) Wrap the cable clockwise around the sheave to pulley C. Then string the cable past pulleys C, D, E, F (tension pulley), G, H, I, J, and K. Tape the cable to the table bottom to maintain tension.

4) While maintaining tension on the cable, rotate the X sheave clockwise (winding cable onto the sheave) to its stop.

5) Use tape to hold the sheave in place. Wrap the cable counter-clockwise around the sheave, through hole L and secure the cable end under the remaining screw. Remove tape from the sheave and from the table bottom.

6) Rotate the sheave counter-clockwise to its stop and move the carriage to the left end of the table. Use screws N and M to clamp cable under both ends of the carriage; the carriage must be clamped perpendicular to the cable.

7) Check the tension on the horizontal axis cable and adjust according to Paragraph 5-2. A. 7.

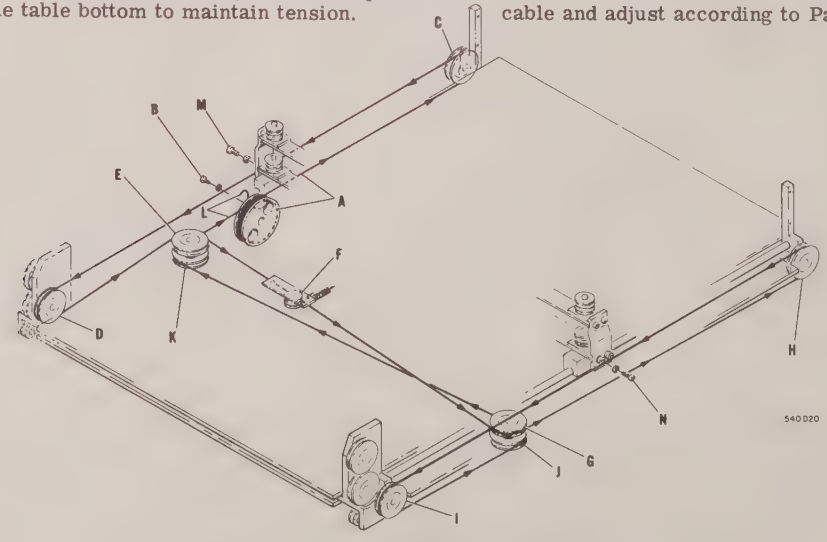


Figure 5-8. Installation of X Axis Cable

SECTION 6
ILLUSTRATED PARTS BREAKDOWN

6-1. GENERAL

The parts list contains all replaceable parts indented under their respective assemblies and subassemblies. The arrangement of the parts list is in dis-assembly sequence within each table, and each assembly is broken down to its lowest replaceable part. An explanation of each column contained in the table follows:

A. REFERENCES

This triple column lists: (1) the figure number of the illustration on which a particular index number or schematic reference will be found; (2) the index number of an item which is used to locate the item in its next higher assembly illustration; (3) the schematic assembly or item reference designation which is used to locate electrical and electronic assemblies and/or items in their next higher assembly illustrations and schematic diagrams.

B. DESCRIPTION

This column lists, in most cases, the approved Government item name and modifiers as contained in Cataloging Handbook H6-1. In the case of standard electronic items and hardware, additional data has been added to the description to enable procurement of a replacement item from local commercial sources.

In some cases, specific models within the series require different components. To identify any restriction in the use of a given component, the following code has been included in the "Description" column.

CODE	EXPLANATION
none	Item used on all models.
B	Item used on Model 540 only.
T	Item used on Model 540T only.
M	Item used on Model 540M only.
TM	Item used on Model 540TM only.

C. MANUFACTURER'S CODE AND PART NUMBER

This column lists the manufacturer's Federal Supply Code as contained in the Federal Supply Code for Manufacturers (Cataloging Handbook H4-2) and manufacturer's part number. For those items where these columns are left blank, procurement must be made from Esterline Angus, Box 24000, Indianapolis, Indiana 46224.

The Federal Supply Codes for manufacturers of items used in this equipment, and contained in the parts list, are listed in paragraph 6-2.

Note

In most instances where composition fixed resistor, film fixed resistors, and standard hardware appear in the parts list, the Government Specification part number or Government Standard part number shown may identify an acceptable replacement item and not necessarily an identical replacement item.

D. E. A. PART NUMBER

This column lists the Esterline Angus number for an item. This number must be used whenever procurement is being made from Esterline Angus.

E. QUANTITY PER ASSEMBLY

This column lists the number of times an item is used in its next higher assembly at the location indicated by the figure and index number.

F. SPARES

This column lists the recommended number of spare parts required to support an equipment for one year. The spare parts recommended are mostly insurance type items and the quantity was calculated on the basis of an equipment in operation for six days a week and 8 hours per day or 2,500 hours of operation.

6-2. MANUFACTURERS

The following is a list of manufacturer's Federal Supply Codes appearing in the parts list along with the name and address of the manufacturer.

CODE	NAME AND ADDRESS
00141	PIC Design Group 477 Atlantic Ave. E. Rockwell, L. I., N. Y 11518

CODE	NAME AND ADDRESS
01002	General Electric Co. Industrial and Power Capacitor Dept. Hudson Falls, N. Y. 12839
01121	Allen-Bradley Co. 1201 South 2nd Street Milwaukee, Wisconsin 53204
02111	Spectrol Electronics Corp. 17070 E. Gale Ave. City of Industry, California 91745
02660	Amphenol Corp. 2801 South 25th Ave. Broadview, Ill. 60153
03038	Long-Lok Corp. 1425 Gateway East Bldg. Los Angeles, California 90067
03797	Eldema Corp. 18435 Susanna Road Compton, California
05341	Bearing Engineers, Inc. 3001 South Broadway Los Angeles, California 90007
06001	General Electric Capacitor Dept. P. O. Box 158 Irmo, South Carolina 29063
06476	Plastic Eng. & Mfg. Corp. 2800 South Elati Englewood, Colorado 80110
07263	Fairchild Camera and Instrument Corp. Semiconductor Division 313 Frontage Road Mountain View, California
11236	CTS of Berne, Inc. 406 Parr Road Berne, Indiana 46711
13786	Magnetic Devices, Inc. 7564 Broadway Lemon Grove, California 92045
14655	Cornell & Dubilier Electric Corp. 50 Paris Street Newark, New Jersey
16228	Brevel Products Corp. Broad and 16th Streets Carlstadt, New Jersey 07072
17254	Litton Precision Products, Inc. Clifton Precision Products Div. 425 E. Fillmore St. Colorado Springs, Colorado 80907
17866	Dietzgen Eugene Co. 2425 Sheffield Road Chicago, Illinois 60614

CODE	NAME AND ADDRESS
18702	Ducommum Metals & Supply 3890 South Alameda St. Los Angeles, California 90058
19845	Columbia Specialty Co., Inc. 6301 Eastern Ave. Baltimore, Maryland 21224
21335	The Fafnir Bearing Co. Division of Textron Inc. 37 Booth Street New Britian, Connecticut 06050
21604	Buckeye Stamping Co. 555 Marion Road Columbus, Ohio 43207
22229	Union Carbide Corp. Electronics Division 365 Middlefield Road Mountain View, California 94041
28009	Honeywell Inc. Test Instruments Division 4800 East Dry Creek Road Denver, Colorado 80217
28520	Heyman Mfg. Co. 147 N. Michigan Ave. Kenilworth, New Jersey 07033
32293	Intersil Inc. 10900 North Tantau Ave. Cupertino, California 95014
53800	Sears, Roebuck & Co. 403 South State St. Chicago, Illinois
56289	Sprague Electric Co. Marshall Street North Adams, Mass. 91247
60399	Torrington Mfg. Co. 100 Franklin Drive Torrington, Connecticut 06790
70318	Allmetal Screw Products Co., Inc. 821 Stewart Ave. Garden City, New York 11533
70472	Associated Spring Corp. 100 Wallace Street Briston, Conn. 06010
71041	Boston Gear Works Broad and 16th Streets Philadephia, Pa. 19140
71400	McGraw-Edison Co. Bussman Manufacturing Div. 2536 W. University St. St. Louis, Missouri 63017

CODE	NAME AND ADDRESS
72264	Esterline Angus Box 24000 Indianapolis, Indiana 46224
72954	Hackensack Cable Corp. 110 Orchard St. Hackensack, New Jersey
72962	Elastic Stop Nut Corp. of America 2330 Vauhall Road Union, New Jersey 07083
73138	Beckman Instruments Inc. Helipot Division 2500 Harbor Blvd. Fullerton, California 92634
73445	Amperex Electronics Corp. 230 Duffy Ave. Hicksville, Long Island, New York 11801
73734	Federal Screw Products Inc. 3917 N. Kenzie Ave. Chicago, Illinois 60618
73760	ITT General Controls Inc. 801 Allen Ave. Glendale, California 91201
73949	Guardian Electric Mfg. Co. 1550 W. Carroll Ave. Chicago, Illinois 60607
75915	Littlefuse, Inc. 800 East Northwest Hwy. Des Plaines, Illinois 60016
80294	Bourns Inc. 1200 Columbia Ave. Riverside, California 92507
81071	Shauer Mfg. Co. 4500 Alpine Ave. Cincinnati, Ohio 45242
81349	Military Specifications Premulgated by Standardization Div. Directorate of Logistic Services DSP
82389	Switchcraft, Inc. 5527 N. Elston Ave. Chicago, Illinois 60630
83086	New Hampshire Ball Bearings, Inc. Peterborough, New Hampshire 03458
83330	Herman H. Smith, Inc. 812 Snediker Ave. Brooklyn, New York 11207
83910	Illinois Tool Works, Inc. Buildex Division St. Charles Road Elgin, Illinois 66120
84830	Lee Spring Co., Inc. 30 Main Street Brooklyn, New York 11201
86928	Seastrom Mfg. Co., Inc. 701 Sonora Avenue Glendale, California 91201
91637	Dale Electronics, Inc. P. O. Box 609 Columbus, Nebraska 68601
91929	Honeywell Inc. Micro Switch Division Chicago and Spring Streets Freeport, Illinois 61032
96881	Thomson Industries, Inc. 1029 Plandome Road Manhasset, New York 11030
96906	Military Standards Standardization Division Directorate of Logistic Services DSA

6-3. ORDERING INFORMATION

When ordering spare or replacement parts, always specify the Esterline Angus part number, description, next higher assembly part number, model number, and equipment serial number. This information will ensure delivery of the required spare or replacement part within the shortest possible time.

6-4. PARTS LIST AND ILLUSTRATIONS

The following tables list all replaceable parts used in the equipment. These tables provide a means of locating spare or replacement part information through the use of appropriate references to illustrations.

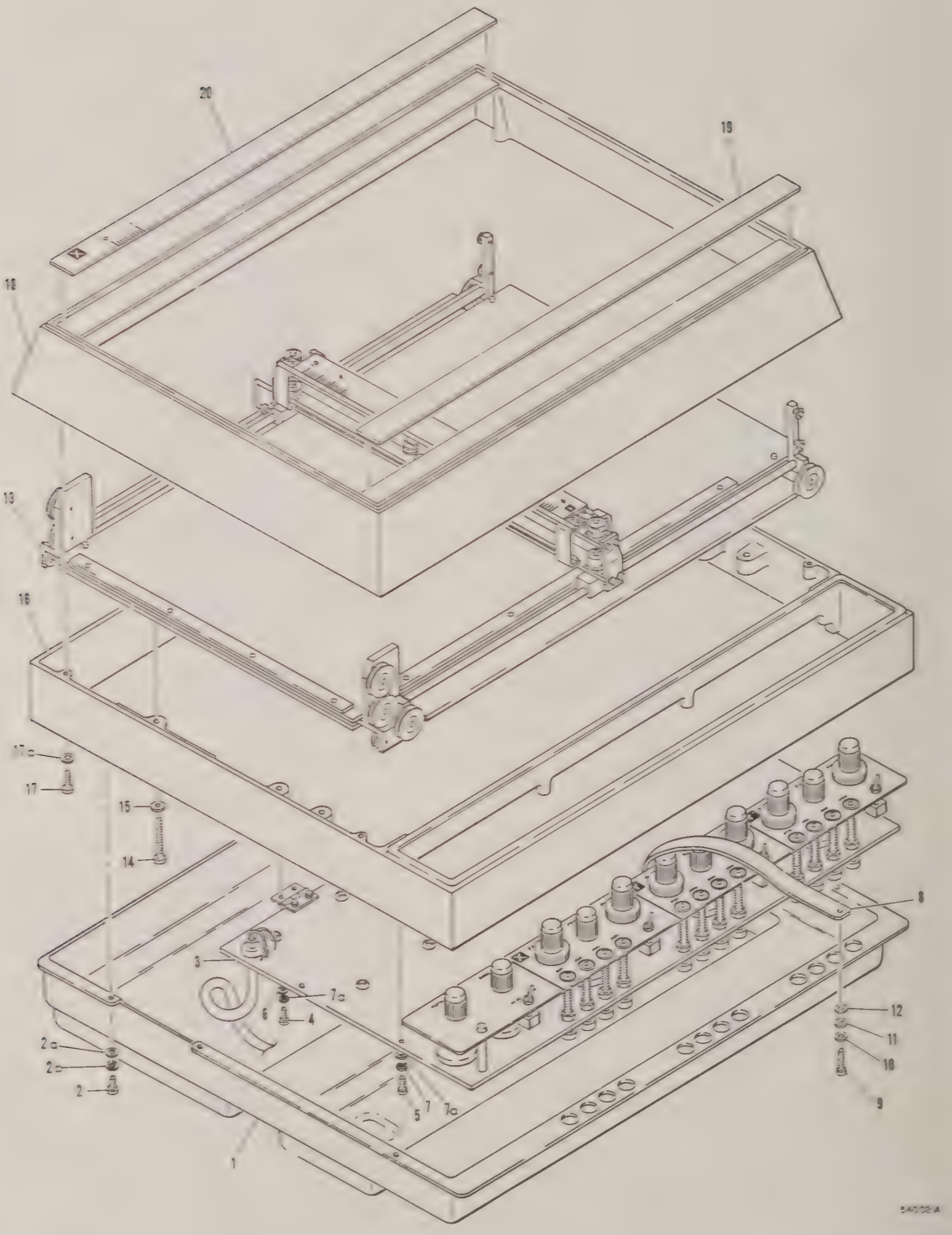


Figure 6-1. Model 540 Chassis Assembly

References			Description	Manufacturer's		E. A. Part No.	Qty/ Assy	Spares
Fig	Index	Schem		Code	Part Number			
			RECORDER, X-Y-Y', Model 540B			16771166-001	1	
			RECORDER, X-Y-Y', Model 540T			16771166-002	1	
			RECORDER, X-Y-Y', Model 540M			16771166-003	1	
			RECORDER, X-Y-Y', Model 540TM			16771166-004	1	
6-1	1		. COVER ASSEMBLY, Bottom (See Figure 6-2 for detail)			16771160-002	1	
			(ATTACHING PARTS)					
	2		. SCREW, P.H., 4-40 by 5/16 IN.	80806	MS35206-214	16765278-214	6	
	2A		. WASHER, Flat, NO. 4	88044	5702-4-32	16755674-006	6	
	2B		. WASHER, Lock, NO. 4	88140	1204-00	16750431-003	6	
			. Case Assembly, Carring			16771162-002	1	
			. NAMEPLATE			16766026-001	1	
			. CHASSIS ASSEMBLY			16771157-001	1	
	3		. . MOTHER BOARD ASSEMBLY(B)			16770951-009	1	
	3		. . MOTHER BOARD ASSEMBLY(T)			16770951-010	1	
	3		. . MOTHER BOARD ASSEMBLY(M)			16770951-011	1	
	3		. . MOTHER BOARD ASSEMBLY(TM) (See Figure 6-9 for detail)			16770951-012	1	
			(ATTACHING PARTS)					
	4		. . SCREW, P.H., 6-32 by 3/8 IN.	80806	MS35206-228	16765278-235	4	
	5		. . SCREW, P.H., 4-40 by 5/16 IN.	80806	MS35206-214	16765278-214	6	
	6		. . WASHER, Lock, NO. 6	88044	1206-00	16750431-005	4	
	7		. . WASHER, Lock, NO. 4	88044	1204-00	16750431-003	6	
	7A		. . WASHER, Flat, NO. 4	88044	5702-4-32	16755674-006	6	
	8		. . RESTRICTOR, Board			16766064-001	1	
			(ATTACHING PARTS)					
	9		. . SCREW, P.H., 6-32 by 1/2 IN.	80806	MS35206-230	16765278-237	2	
	10		. . WASHER, Lock, NO. 6	88044	1206-00	16750431-005	2	
	11		. . WASHER, Flat, NO. 6	88044	5702-12-32	16755674-008	2	
	12		. . WASHER, Fiber	88044	5602-105-062	16750436-012	2	
	13		. . TABLE ASSEMBLY, Main (See Figure 6-3 for detail)			16771139-001	1	
			(ATTACHING PARTS)					
	14		. . SCREW, P.H., 6-32 by 3/4 IN.	80806	MS35206-232	16765278-239	4	
	15		. . WASHER, Lock, NO. 6	88044	1206-00	16750431-005	4	
	16		. . FRAME			16771158-001	1	
			. BEZEL ASSEMBLY			16771161-001	1	
			(ATTACHING PARTS)					
	17		. SCREW, P.H., 4-40 by 5/8 IN.	80806	MS35206-218	16765278-218	4	
	17A		. WASHER, LOCK, NO. 4	88044	1204-00	16750431-003	4	
	18		. . BEZEL			16771162-001	1	
	19		. . DECAL, Lower, identification			16771165-003	1	
	20		. . DECAL, Upper, inch scale (B, T)			16771164-001	1	
	20		. . DECAL, Upper, metric scale M, TM)			16771163-001	1	
			. BRACKET Assembly, 1 Pen.			16774970-001	1	4
			. BRACKET Assembly, 2 Pen.			16774971-001	1	4
			. KIT ASSEMBLY, Accessory (B, T)			16771167-001	1	
			. KIT ASSEMBLY, Accessory (B, TM)			16774975-001	1	
			. . Marker, Fiber Red			16774972-111	1 set	
			. . Marker, Fiber Green			16774972-112	1 set	

References			Description	Manufacturer's		E. A. Part No.	Qty/ Assy	Spares
Fig	Index	Schem		Code	Part Number			
			. . CONNECTOR, Plug, electrical 24 pins	02660	57-30240	16750110-013	1	
			. . KIT, Accessory, rack mount			16805024-001	1	
			. . . BAR, Rack mount, L. H.			16805115-001	1	
			(ATTACHING PARTS)					
			. . . SCREW, P.H., 10-32 by 1/2 IN.	96906	MS35207-263	16765279-297	4	
			- - - * - - -					
			. . . BAR, Rack mount, R. H.			16805114-001	1	
			(ATTACHING PARTS)					
			. . . SCREW, P. H., 10-32 by 1/2 IN.	96906	MS35207-263	16765279-297	4	
			- - - * - - -					
			. . . EAR, Rack Mount			16805116-001	2	
			(ATTACHING PARTS)					
			. . . SCREW, F. L. H., 6-32 by 3/8 IN.			16765283-046	6	
			. . . SCREW, Set, 8-32 by 3/8 IN.	96906	MS51963-24	16761013-037	2	
			. . . WASHER, Lock, INT tooth NO. 6	83910	1206-00	16750431-005	6	
			- - - * - - -					
			. . KIT, Tool			16771495-001	1	
			. . . WRENCH, Allen, NO. 4	18702	A Dim. 0.050 IN.	16769256-105	1	
			. . . WRENCH, Allen, NO. 6	18702	A Dim. 1/16 IN.	16769256-107	1	
			. . . WRENCH, Allen, NO. 8	18702	A Dim. 5/64 IN.	16769256-109	1	
			. . . WRENCH, Allen	18702	A Dim. 7/64 IN.	16769256-113	1	
			. . MANUAL, Technical			16771168-001	1	
			. . PAPER, Graph, (B, T)			16800046-001	1 bx	*5 bx
			. . PAPER, Graph, (M, TM)			16800543-001	1 bx	*5 bx
			. . DUST COVER, Vinyl	06476	500	16800527-001	1	
			. SET, Maintenance stand (Optional)			16771566-001	1	
		2	. CABLE, Bergen, 30 FT (Optional)			16771782-001	30 FT	2 rolls

1 Not available separately-Buy NHA
2 Not supplied with recorder
* Select according to usable on code

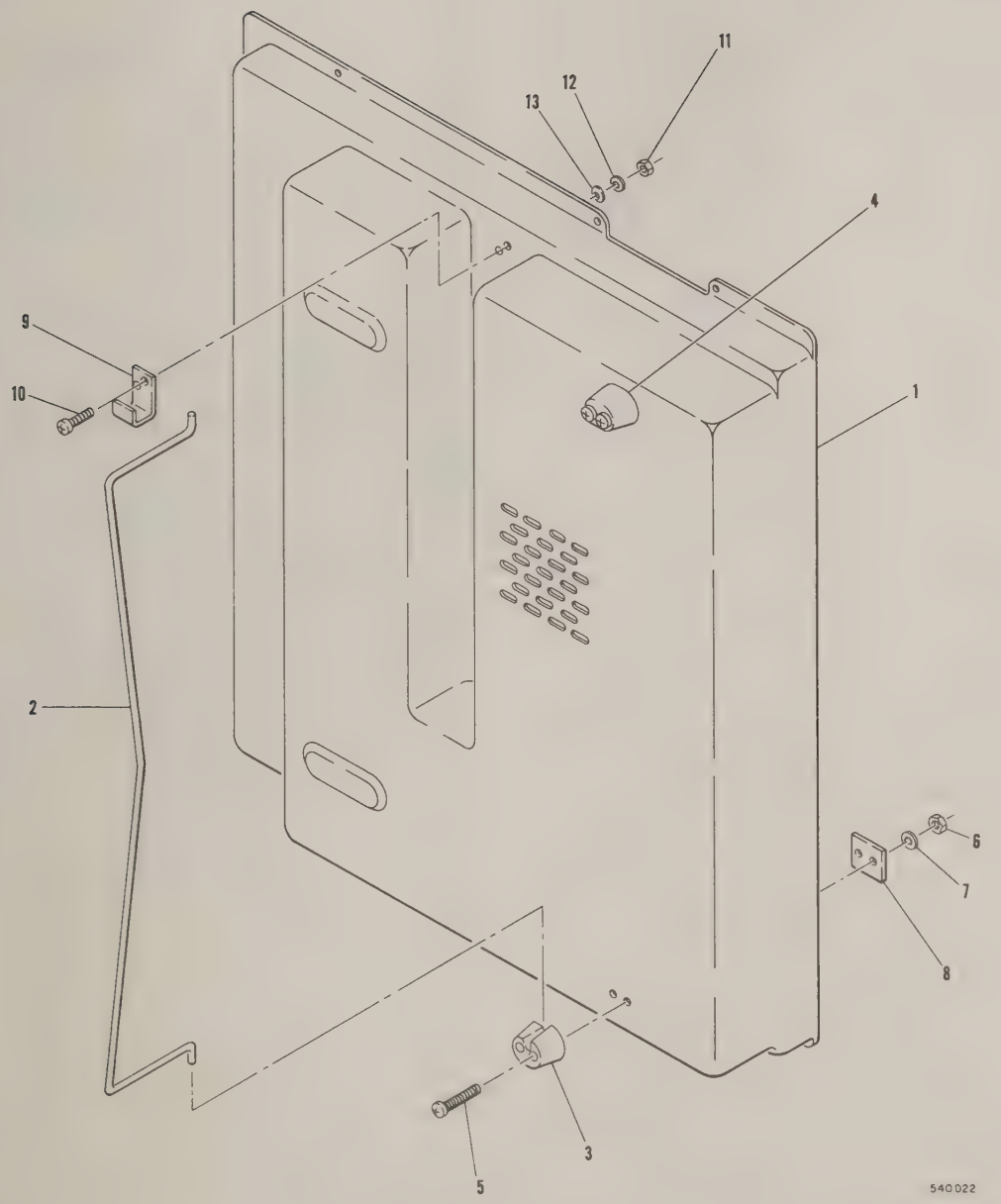


Figure 6-2. Bottom Cover Assembly

References			Description	Manufacturer's		E. A. Part No.	Qty/ Assy	Spares
Fig	Index	Schem		Code	Part Number			
			COVER ASSEMBLY, Bottom			16771159-001	REF	
6-2	1		. COVER, Bottom			16771160-002	1	
	2		. BAIL, Tilt			16766884-001	1	
	3		. BUMPER, Plastic	21604	PP40012-1	16800695-001	1	
	4		. BUMPER, Plastic	21604	PP40012-2	16800695-002	1	
			(ATTACHING PARTS)					
	5		. SCREW, P.H., 6-32 by 5/8 IN.	96906	MS35206-231	16765278-238	4	
	6		. NUT, Hex, 6-32	96906	MS35649-262	16755689-007	4	
	7		. WASHER, Lock, INT tooth, NO. 6	83910	1206-00	16750431-005	4	
	8		. PLATE, Support			16805061-001	2	
			- - - * - - -					
	9		. HOLDER, Cord			16771767-001	2	
			(ATTACHING PARTS)					
	10		. SCREW, P.H., 6-32 by 3/8 IN.	96906	MS35206-228	16765278-235	4	
	11		. NUT, Hex, 6-32	96906	MS35649-262	16755689-007	4	
	12		. WASHER, Lock, INT tooth, NO. 6	83910	1206-00	16750431-005	4	
	13		. WASHER, Flat, NO. 6	86928	5702-12-32	16755674-008	4	
			- - - * - - -					

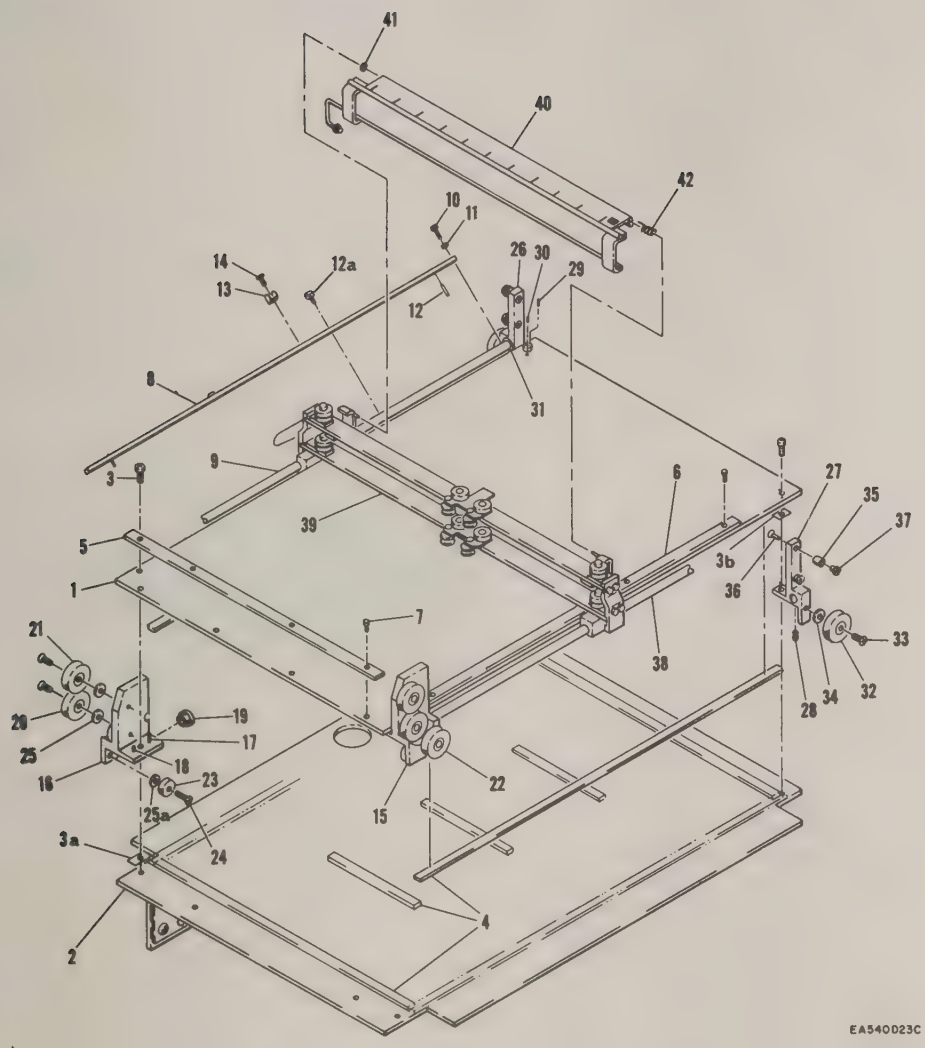


Figure 6-3. Main Table Assembly

References			Description	Manufacturer's		E. A. Part No.	Qty/ Assy	Spares
Fig	Index	Schem		Code	Part Number			
			TABLE ASSEMBLY, Main			16771139-001	REF	
6-3	1		. TABLE, Main			16771498-001	1	
	2		. SUB-TABLE ASSEMBLY			16771140-001	1	
			(ATTACHING PARTS)					
	3		. SCREW, Self locking, 6-32 by 1/2 IN.	03038	Y4-6-W-LL	16770893-026	4	
			- - - * - - -					
	3A		. Spacer, Plate			16776426-002	2	
	3B		. Spacer, Plate			16776426-001	2	
	4		. FOAM, 1/8 IN. THK x 1/4 IN. WD x 72 IN. LG, white	26066	Y-9132	16501863-001	72 IN.	
	5		. STOP, Paper, horizontal			16771500-001	1	
	6		. STOP, Paper, vertical			16771499-001	1	
			(ATTACHING PARTS)					
	7		. SCREW, FIL. H., 4-40 by 1/4 IN.		COML	16761004-024	8	
			- - - * - - -					
			. PEN LIFT ASSEMBLY			16771142-001	1	
	8		. . ROD, Guide, top			16771509-001	1	
	9		. . BAR, Pen lift			16771510-001	1	
			(ATTACHING PARTS)					
	10		. . SCREW, P.H., 2-56 by 5/16 IN.	96906	MS35206-204	16765278-204	2	
	11		. . WASHER, Lock, INT tooth, NO. 2	83910	1202-00	16750431-001	2	
	12		. . PIN, Spring, .062 by .312 IN.	72962	79-012-062-0312	16750292-004	2	
	12A		. . SCREW, RD. H., 1-72 by 1/4 IN.	70318	COML	16750303-071	2	
			- - - * - - -					
	13		. . BRACKET, Pivot			16805099-002	1	
			(ATTACHING PARTS)					
	14		. . SCREW, RD. H., 1-72 by 1/8 IN.	70318	COML	16750303-069	1	
			- - - * - - -					
	15		. BRACKET ASSEMBLY, Pulley mounting, bottom - left hand			16771144-006	1	
	15		. BRACKET ASSEMBLY, Pulley mounting, top - left hand			16771144-005	1	
	16		. . BRACKET, Mounting, pulley (top - left hand assembly only)			16771630-005	1	
	16		. . BRACKET, Mounting, pulley (bottom - left hand assembly only)			16771630-006	1	
	17		. . PIN, Spring, 1/16 by 3/16 IN.	72962	79-012-062-0187	16750292-002	2	
	18		. . PIN, Spring, 1/16 by 5/16 IN.	72962	79-012-062-0312	16750292-004	2	
	19		. . BEARING, Nylon (top - left hand assembly only)	96881	4L4-F	16800250-003	1	
	20		. . PULLEY ASSEMBLY, 1 IN.			16775577-001	2	1
	21		. . PULLEY ASSEMBLY, 1 IN.			16775577-001	2	1
	22		. . PULLEY ASSEMBLY, 1 IN.			16775577-001	2	1
	23		. . PULLEY ASSEMBLY, 1/2 IN.			16775576-001	2	1
			(ATTACHING PARTS)					
	24		. . SCREW, F.H., 4-40 by 3/8 IN.	96906	MS35190-223	16765280-225	8	
	25		. . WASHER, Flat, NO. 4	86928	5702-8-32	16755674-006	24	
	25A		. . WASHER, Flat, NO. 4		COML	16726638-019	2	
			- - - * - - -					
	26		. BRACKET ASSEMBLY, Pulley mounting, top - right hand			16771143-003	1	
			. BRACKET ASSEMBLY, Pulley mounting, bottom - right hand			16771143-004	1	
			. . BRACKET, Mounting, pulley (top - right hand assembly only)			16771511-007	1	
	27		. . BRACKET, Mounting, pulley (bottom - right hand assembly only)			16771511-008	1	

References			Description	Manufacturer's		B. A. Part No.	Qty/ Assy	Spares
Fig	Index	Schem		Code	Part Number			
6-3	28		. . SCREW, Set, 4-40 by 1/8 IN. (bottom-right hand assembly only)	96906	MS51963-3	16761013-003	1	
	29		. . PIN, Spring, 1/16 by 3/16 IN.	72962	79-012-062-0187	16750292-002	2	
	30		. . PIN, Spring, 1/16 by 5/16 IN.	72962	79-012-062-0312	16750292-004	2	
	31		. . BEARING, Nylon (top - right hand assembly only)	96881	4L4-F	16800250-003	1	
	32		. . PULLEY ASSEMBLY, 1 IN. (ATTACHING PARTS)			16775577-001	2	
	33		. . SCREW, F.H., 4-40 by 3/8 IN.	96906	MS35190-223	16765280-225	2	
	34		. . WASHER, Flat, NO. 4 - - - * - - -	86928	5702-8-32	16755674-006	2	
	35		. . SPACER, 1/8 IN. (ATTACHING PARTS)			16775958-001	4	
	36		. . SCREW, P.H., 4-40 by 3/8 IN.	96906	MS35190-223	16765280-225	4	
	37		. . Insert, Screw Thread - - - * - - -			16775957-001	4	
	38		. . ROD, Guide, bottom			16771146-001	1	
	39		. . CARRIAGE ASSEMBLY (See Figure 6-4 for detail)			16771147-001	1	
	40		. . COVER ASSEMBLY, Carriage (See Figure 6-4 for detail)			16771497-001	1	
	41		. . WASHER, Nylon, NO. 2		COML	16750436-013	1	
	42		. . SPRING, Carriage Cover			16774847-001	1	

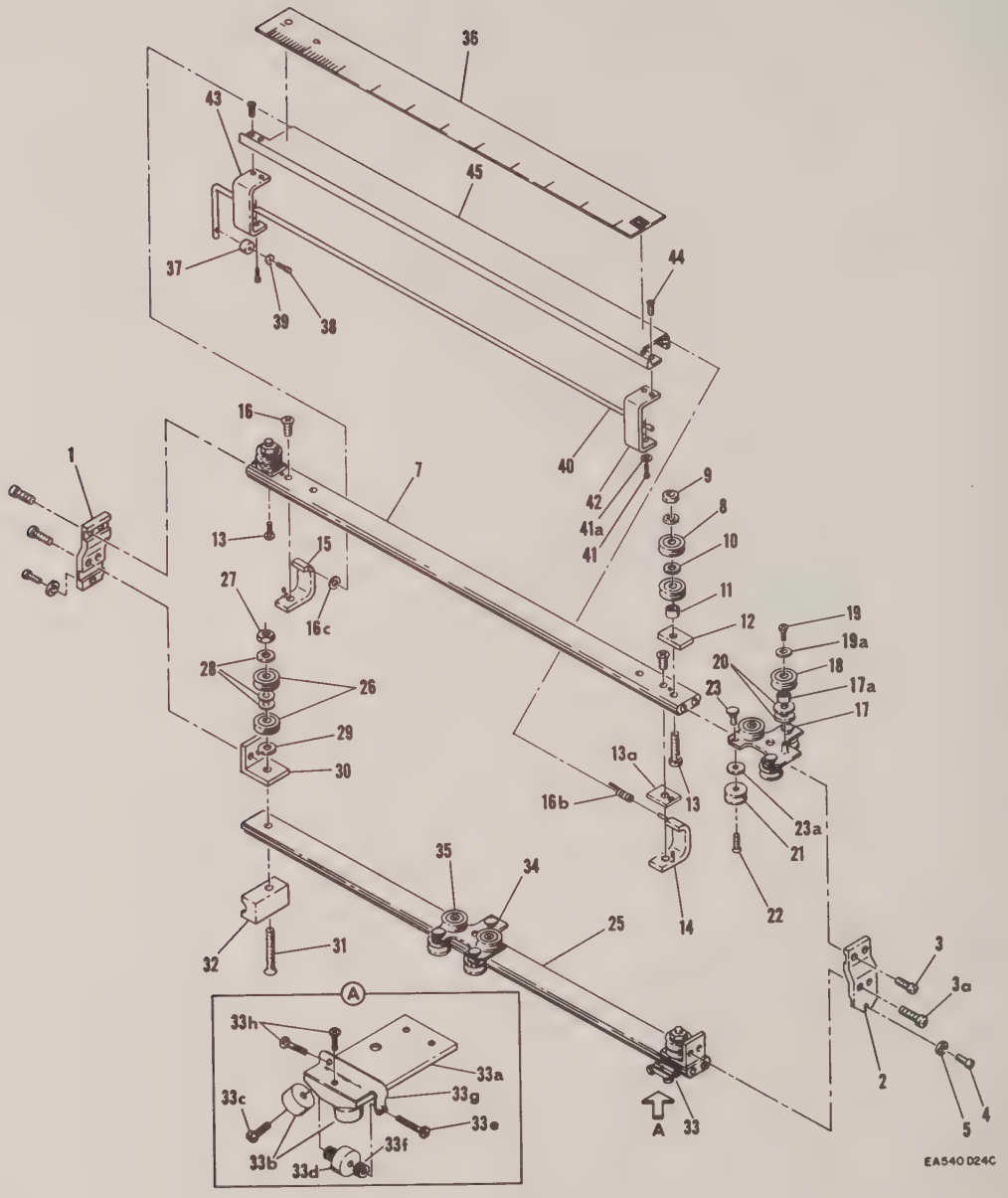


Figure 6-4. Carriage Assembly

References			Description	Manufacturer's		E. A. Part No.	Qty/ Assy	Spares
Fig	Index	Schem		Code	Part Number			
			CARRIAGE ASSEMBLY (See Figure 6-3 for NHA)			16771147-001	REF	
6-4	1,2		. END PLATE, Carriage			16771156-005	2	
			(ATTACHING PARTS)					
	3		. SCREW, R.H., 6-32 by 1/4 IN.			16774615-002	8	
	4		. . SCREW, P.H., 2-56 by 1/8 IN.	96906	MS35206-201	16765278-201	2	
	5		. . WASHER, Flat, NO. 2	86928	5702-4-16	16755674-001	2	
			. CARRIAGE ASSEMBLY, Y'			16771151-001	1	
	7		. . CARRIAGE, Y'			16771513-001	1	
	8		. . PULLEY ASSEMBLY, 1/2 IN.			16775576-001	4	
			(ATTACHING PARTS)					
	9		. . NUT, 4-40			16103100-001	2	
	10		. . WASHER, Flat, NO. 4			16726638-019	2	
	11		. . SPACER, sleeve			19775958-003	2	
	12		. . SPACER, Nut, 4-40			16771514-001	2	
	13		. . SCREW, P. H., 4-40 by 3/4 IN.	96906	MS35206-219	16765278-219	2	
			- - - * - - -					
	13A		. . SPACER			16773487-001	2	
	14		. . PIVOT BRACKET, Bottom			16771515-002	1	
	15		. . PIVOT BRACKET, Top			16771515-001	1	
			(ATTACHING PARTS)					
	16		. . SCREW, F.H., 4-40 by 1/2 IN.	96906	MS35190-225	16765280-227	2	
			- - - * - - -					
	16B		. . SPRING, Compression			16774847-001	1	
	16C		. . WASHER, Nylon, NO. 2			16750436-013	1	
			. . BRACKET ASSEMBLY, Slider			16805044-003	1	
	17		. . . PLATE, Mounting, bearing			16805108-001	1	
	17A		. . . SPACER, sleeve			16775958-002	2	
	18		. . . PULLEY ASSEMBLY, 1/2 IN.			16775576-001	2	
			(ATTACHING PARTS)					
	19		. . . SCREW, F. H., 2-56 by 3/16"	70318	COML	16761000-002	2	
	19A		. . . WASHER, Flat, No. 4	70138	COML	16755674-101	2	
	20		. . . WASHER, Flat, NO. 4			16726638-019	6	
			- - - * - - -					
	21		. . . BEARING, V	83086	SR2-62C	16800246-001	3	
			(ATTACHING PARTS)					
	22		. . . SCREW, F.H., 2-56 by 3/16"	70318	COML	16761000-002	3	
	23		. . . STANDOFF, Shoulder			16805109-001	3	
	23A		. . . WASHER, Flat, No. 4			16726638-019	6	
			- - - * - - -					
			. CARRIAGE ASSEMBLY, Y			16771152-001	1	
	25		. . CARRIAGE, Y			16771512-001	1	
	26		. . PULLEY ASSEMBLY, 1/2 IN.			16775576-001	4	1
			(ATTACHING PARTS)					
	27		. . NUT, 4-40			16103100-001	2	
	28		. . WASHER, Flat, NO. 4			16726638-019	2	
	30		. . BRACKET, Stop			16775234-001	2	
	31		. . SCREW, P. H., 4-40 by 3/4 IN.	96906	MS35206-219	16765278-219	2	
			- - - * - - -					

References			Description	Manufacturer's		E. A. Part No.	Qty/ Assy	Spares
Fig	Index	Schem		Code	Part Number			
6-4	32		. . BEARING, Top			16771154-001	1	
	33		. . BEARING ASSEMBLY, Bottom			16774267-001	1	
	33A		. . . BLOCK, Mounting			16773482-002	1	
	33B		. . . BEARING, Ball	83086	SR1-45PEE	16800248-001	4	
			(ATTACHING PARTS)					
	33C		. . . SCREW, RD. H., 1-72 by 1/4 IN.	70318	COML	16750303-071	4	
			- - - * - - -					
	33D		. . . BEARING, Ball	83086	SR1-45PEE	16800248-001	1	
			(ATTACHING PARTS)					
	33E		. . . SCREW, RD. H., 1-72 by 3/8 IN.	70318	COML	16750303-073	1	
	33F		. . . WASHER, Flat, NO. 1			16750435-001	4	
			- - - * - - -					
	33G		. . . STIRRUP			16773483-001	1	
			(ATTACHING PARTS)					
	33H		. . . SCREW, RD. H., 1-72 by 1/8IN.	70318	COML	16750303-069	2	
	34		. . BRACKET ASSEMBLY, Slider			16805044-002	1	
			. . . PLATE, Mounting, bearing			16805108-001	1	
	35		. . . PULLEY ASSEMBLY, 1/2 IN.			16775576-001	2	
			(ATTACHING PARTS)					
			. . . SCREW, F. H., 2-56 by 1/8 IN.	96906	MS51959-1	16761000-001	2	
			. . . WASHER, Bellville, NO. 4			16726638-019	9	
			- - - * - - -					
			. . . BEARING, V	83086	SR2-62C	16800246-001	3	
			(ATTACHING PARTS)					
			. . . SCREW, F. H., 2-56 by 1/4 IN.	70318	TYPE 430-2-56-1-4	16750313-104	3	
			STANDOFF, Shoulder			16805109-001	3	
			- - - * - - -					
			COVER ASSEMBLY, Carriage (See Figure 6-3 for NHA)			16771497-001	REF	
	36		. DECAL, Inches (B, T)			16771519-001	1	
	36		. DECAL, Metric (M, TM)			16771520-001	1	
	37		. BEARING	83086	SR1-45PEE	16800248-001	1	
			(ATTACHING PARTS)					
	38		. SCREW, R. H., 1-72 by 1/4 IN.	70318	COML	16750303-071	1	
			- - - * - - -					
	40		. ROD, Lifting, lower pen			16771518-002	1	
			(ATTACHING PARTS)					
	41		. SCREW, P. H., 2-56 by 3/16 IN.	96906	MS35206-202	16765278-202	2	
	41A		. WASHER, Lock, INT tooth, No. 2	83910	1202-00	16750431-001	2	
			- - - * - - -					
	42		. BRACKET, Pen lift			16771516-002	2	
			(ATTACHING PARTS)					
	44		. SCREW, F. H., 2-56 by 1/8 IN.	96906	MS51959-1	16761000-001	4	
			- - - * - - -					
	45		. COVER, Carriage			16771145-001	1	

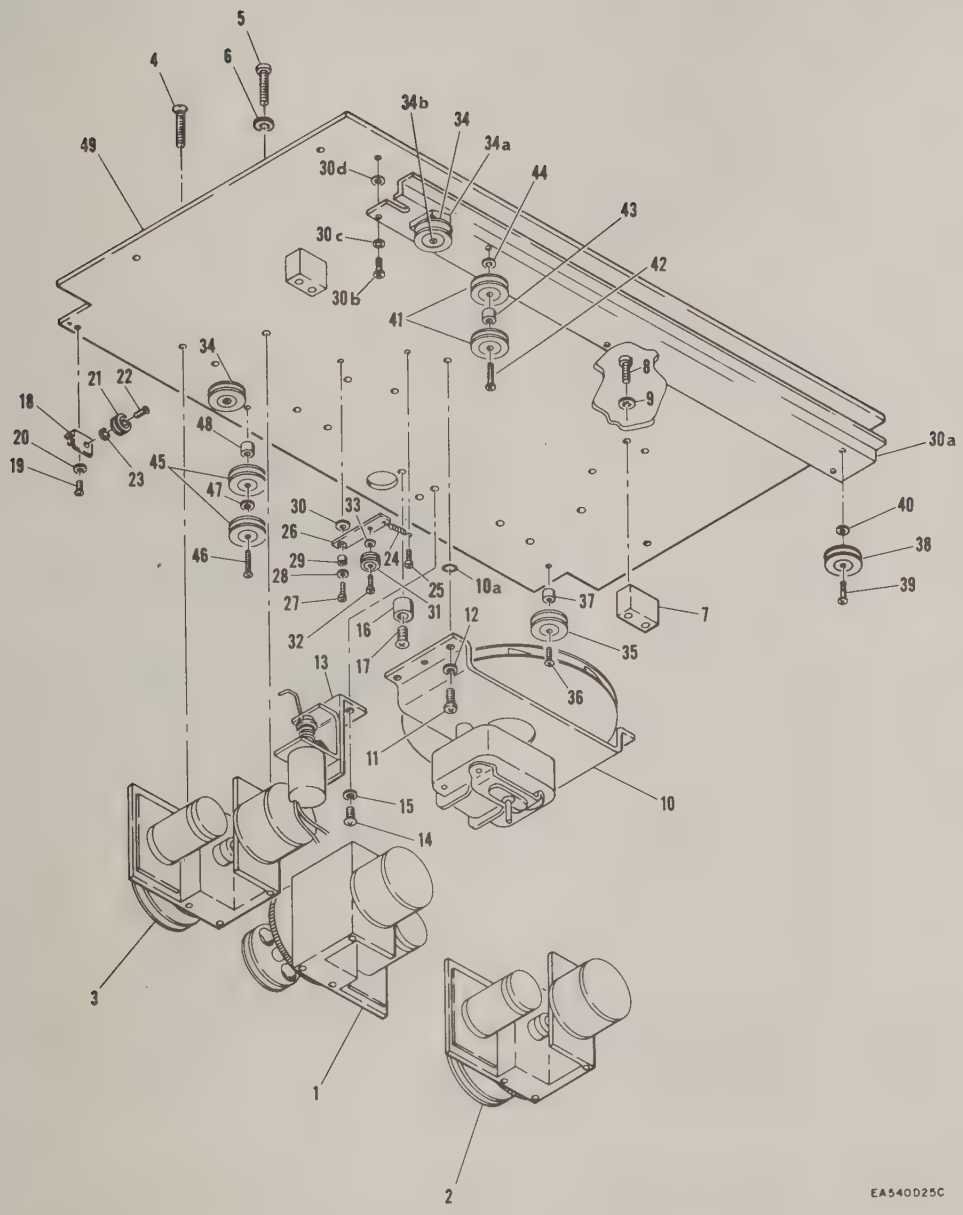


Figure 6-5. Sub Table Assembly

References			Description	Manufacturer's		E. A. Part No.	Qty/ Assy	Spares
Fig	Index	Schem		Code	Part Number			
			SUB-TABLE ASSEMBLY			16771140-001	REF	
6-5	1		. DRIVE ASSEMBLY, Servo, X (See Figure 6-7 for detail)			16771133-002	1	
	2,3		. DRIVE ASSEMBLY, Servo, Y, Y' (See Figure 6-7 for detail)			16771134-002	1	
			(ATTACHING PARTS)					
	4		. SCREW, F.H., 6-32 by 3/8 IN.	96906	MS35190-236	16765280-245	6	
	5		. SCREW, P.H., 6-32 by 3/8 IN.	96906	MS35206-228	16765278-235	3	
	6		. WASHER, Lock, INT tooth, NO. 6	83910	1206-00	16750431-005	3	
			- - - * - - -					
	7		. BLOCK, Support			16771502-001	2	
			(ATTACHING PARTS)					
	8		. SCREW, P.H., 6-32 by 5/16 IN.	96906	MS35206-227	16765278-234	4	
	9		. WASHER, Lock, INT tooth, NO. 6	83910	1206-00	16750431-005	4	
			- - - * - - -					
	10		. BRACKET ASSEMBLY, Vacuum motor (See Figure 6-6 for detail)			16774185-001	1	
			(ATTACHING PARTS)					
	10A		. "O" RING, Rubber			16726367-006	3	
	11		. SCREW, P.H., 6-32 by 3/8 IN.	96906	MS35206-228	16765278-235	3	
	12		. WASHER, Lock, INT tooth, NO. 6	83910	1206-00	16750431-005	3	
	13		. SOLENOID ASSEMBLY (See Figure 6-8 for detail)			16775293-001	1	
			(ATTACHING PARTS)					
	14		. SCREW, P.H., 6-32 by 5/16 IN.	96906	MS35206-227	16765278-234	2	
	15		. WASHER, Lock, NO. 6		COML	16755632-003	2	
			- - - * - - -					
	16		. RESTRICTOR (Stop)			16805079-002	1	
			(ATTACHING PARTS)					
	17		. SCREW, F.H., 4-40 by 3/4 IN.	96906	MS35190-227	16765280-229	1	
			- - - * - - -					
	18		. BRACKET, Cable deflecting			16771503-001	1	
			(ATTACHING PARTS)					
	19		. SCREW, P.H., 4-40 by 1/4 IN.	96906	MS35206-213	16765278-213	1	
	20		. WASHER, Lock, INT tooth, NO. 4	83910	1204-00	16750431-003	1	
			- - - * - - -					
	21		. PULLEY ASSEMBLY, 1/2 IN.			16775576-001	1	
			(ATTACHING PARTS)					
	22		. SCREW, F.H., 4-40 by 5/16 IN.	96906	MS35190-222	16765280-224	1	
	23		. WASHER, Flat, NO. 4			16726638-019	1	
			- - - * - - -					
	24		. SPRING, Extension	84830	E1-010B-5	16771505-001	1	
	25		. SCREW, P.H., 2-56 by 3/16 IN.	96906	MS35206-202	16765278-202	1	
	26		. BAR, Tension			16771504-001	1	
			(ATTACHING PARTS)					
	27		. SCREW, P.H., 4-40 by 1/4 IN.	96906	MS35206-213	16765278-213	1	
	28		. WASHER, Flat, NO. 4	86928	5702-8-32	16755674-006	1	
	29		. SPACER, 1/8 IN.	11237	212-45-004-01-22	16800258-002	1	

References			Description	Manufacturer's		E. A. Part No.	Qty/ Assy	Spares
Fig	Index	Schem		Code	Part Number			
6-5	30		. WASHER, Flat, NO. 8	86928	5702-16-32	16755674-010	1	
			- - - * - - -					
	30A		. SHIELD			16773327-001	1	
			(ATTACHING PARTS)					
	30B		. SCREW, P.H., 4-40 by 1/4 IN.	96906	MS35206-213	16765278-213	3	
	30C		. WASHER, Lock, INT tooth, NO. 4	83910	1204-00	16750431-003	3	
	30D		. WASHER, Flat, NO. 4 (Located between sub-table and shield)	86928	5702-8-32	16755674-006	3	
			- - - * - - -					
	31		. PULLEY, 1/2 IN.			16775576-001	1	
			(ATTACHING PARTS)					
	32		. SCREW, F. H., 4-40 by 5/16 IN.	96906	MS35190-222	16765280-224	1	
	33		. WASHER, Flat, NO. 4, S. P.			16726638-019	1	
			- - - * - - -					
	34		. PULLEY ASSEMBLY, 1 IN.			16775577-001	2	
	34A		. BLOCK, Spacer			16774133-001	1	
	34B		. SCREW, F. H., 4-40 by 5/8 IN.	90696	MS35190-226	16765280-228	1	
	35		. PULLEY ASSEMBLY, 1 IN.			16775577-001	1	
			(ATTACHING PARTS)					
	36		. SCREW, F. H., 4-40 by 1/2 IN	96906	MS35190-225	16765280-227	2	
	37		. STANDOFF, 1/4 IN.	83330	4100	16769123-100	2	
			- - - * - - -					
	38		. PULLEY ASSEMBLY, 1 IN.			16775577-001	1	
			(ATTACHING PARTS)					
	39		. SCREW, F.H., 4-40 by 5/16 IN.	96906	MS35190-222	16765280-224	1	
	40		. WASHER, Flat, NO. 4	86928	5702-8-32	16755674-006	1	
			- - - * - - -					
	41		. PULLEY ASSEMBLY, 1 IN.			16775577-001	2	
			(ATTACHING PARTS)					
	42		. SCREW, F.H., 4-40 by 5/8 IN.	96906	MS35190-226	16765280-228	1	
	43		. STANDOFF, 1/8 IN.			16759850-221	1	
	44		. WASHER, Flat, NO. 4	86928	5702-8-32	16755674-006	1	
			- - - * - - -					
	45		. PULLEY ASSEMBLY, 1 IN.			16775577-001	2	
			(ATTACHING PARTS)					
	46		. SCREW, F.H., 4-40 by 5/8 IN.	96906	MS35190-226	16765280-228	1	
	47		. WASHER, Flat, NO. 4	86928	5702-8-32	16755674-006	1	
	48		. STANDOFF, 1/4 IN.	83330	4100	16769123-100	1	
			- - - * - - -					
	49		. SUB-TABLE			16771148-003	1	

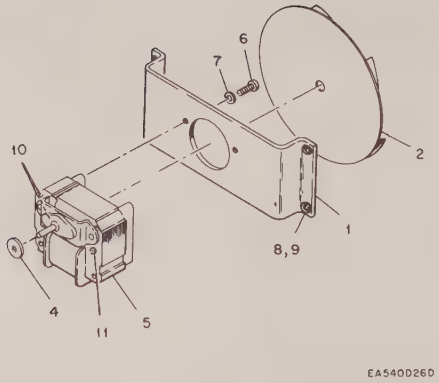


Figure 6-6. Motor Bracket Assembly

References			Description	Manufacturer's		E. A. Part No.	Qty/ Assy	Spares
Fig	Index	Schem		Code	Part Number			
			BRACKET ASSEMBLY, Motor vacuum (See Figure 6-5 for NHA)			16774185-001	REF	
6-6	1		. BRACKET, Mounting, vacuum			16774583-001	1	
	2		. FAN, Vacuum			16800153-003	1	
	4		. WASHER, Felt			16776926-001	1	
	5	B1	. MOTOR, 115 Vac, 60 Hz	16228	M14-1C2-F7-820AET-1	16774978-001	1	1
	6		. SCREW, P. H., 6-32 by 1-5/8 IN.			1HS-632-26D		
	7		. WASHER, Lock, INT tooth, NO. 6	83910	1210-00	16750431-005	2	
	8		. GROMMET, Rubber			ND40180-21	3	
	9		. BUSHING, Brass			21596	3	
	10		. WASHER, Flat			ND40145-2	A/R	
	11		. NUT, Hex, 6-32			NX2006	2	

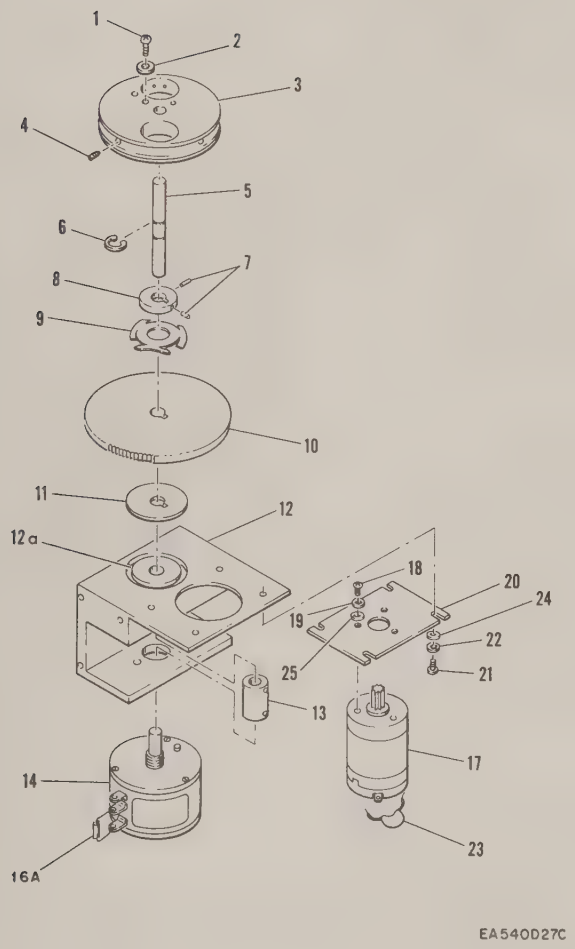


Figure 6-7. Drive Assembly

References			Description	Manufacturer's		E. A. Part No.	Qty/ Assy	Spares
Fig	Index	Schem		Code	Part Number			
			DRIVE ASSEMBLY, Servo, X axis (See Figure 6-5 for NHA)			16771133-002	1	
			DRIVE ASSEMBLY, Servo, Y and Y' axis (See Figure 6-5 for NHA)			16771134-002	1	
6-7	1		. SCREW, P.H., 4-40 by 1/4 IN.	96906	MS35206-213	16765278-213	6	
	2		. WASHER, Flat, NO. 4	86928	5702-8-32	16755674-006	6	
	3		. SHEAVE, X axis			16805277-001	1	
			(ATTACHING PARTS)					
	4		. SCREW, Set, 6-32 by 1/4 IN.	96906	MS51963-22	16761013-022	2	
			- - - * - - -					
			. SHEAVE, Y and Y' axis			16805271-001	2	
			(ATTACHING PARTS)					
			. SCREW, Set, 6-32 by 1/4 IN.	96906	MS51963-22	16761013-022	4	
			- - - * - - -					
			. SHAFT ASSEMBLY, Servo			16774183-002		
	5		. . SHAFT			16771136-002	3	
	6		. . RING, Retaining, snap type	00141	Z3-3	16800182-003	6	
	7		. . SCREW, Set 2-56			16761013-003	6	
	8		. . CLUTCH, Hub			38421011-001	3	
	9		. . WASHER, Bearing, spring	70472	S-10-B	16800191-001	3	
	10		. . GEAR, Spur			16805088-002	3	3
	11		. . WASHER, Flat, fiber,			16771506-004	3	
	12		. BRACKET, Servo			16771132-002	3	
	12A		. BEARING, Flange	21335	FS14DD7FS160	16750791-009	3	
	13		. COUPLING, shaft	83330	120	16755037-001	3	
	14	R137, R237, R337	. RESISTOR, Variable, precision, 5K, 0.1%	02111	830-121	16800064-002	3	4
			(ATTACHING PARTS)					
	15		. NUT (Part of NHA)			No Number	1	
	16		. WASHER, Flat (Part of NHA)			No Number	1	
	16A	R135, R235, R335	. RESISTOR, Fixed, selected (Specify Value)				3	
			- - - * - - -					
			. MOTOR ASSEMBLY, Servo			16775416-002	3	
	17	M101, M201, M301	. . MOTOR, Servo, DC, permanent magnet			16800045-002	3	
			(ATTACHING PARTS)					
	18		. . SCREW, P.H., 2-56 by 5/16 IN.	96906	MS35206-205	16765278-204	9	
	19		. . WASHER, Lock, NO. 2	83910	1206-00	16750431-001	9	
	25		. . WASHER, Flat, NO. 2	86928	5702-4-16	16755674-001	9	
			- - - * - - -					
	20		. . BRACKET, Isolation, motor			16771137-001	3	
	21		. . SCREW, P.H., 6-32 by 1/4 IN.	96906	MS35206-226	16765287-233	12	
	22		. . WASHER, Lock, NO. 6	83910	1206-00	16750431-005	12	
	23	C112, C212, C312	. . CAPACITOR, Fixed ceramic, 0.01UF, 50VDC	56289	C023B101F103Z	16757455-002	3	
	24		. . WASHER, Flat, NO. 6			16755674-008	24	

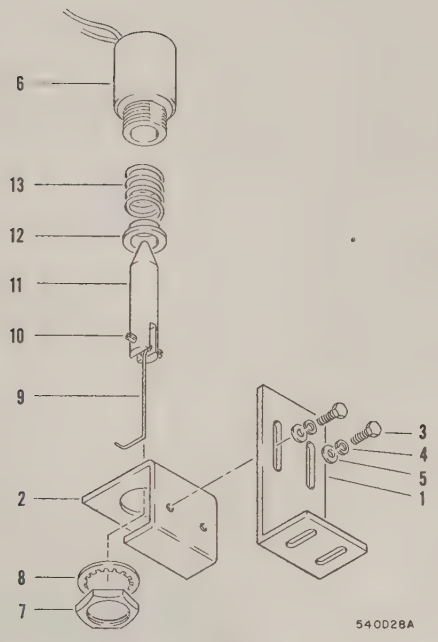


Figure 6-8. Solenoid Assembly

References			Description	Manufacturer's		E. A. Part No.	Qty/ Assy	Spares
Fig	Index	Schem		Code	Part Number			
			SOLENOID ASSEMBLY (See Figure 6-5 for NHA)			16775293-001	REF	
6-8	1		. BRACKET, Angle			16775340-001	1	
	2		. BRACKET, Subassembly			16775367-001	1	
			(ATTACHING PARTS)					
	3		. SCREW, Hex Hd 6-32 by 3/8 IN.		COML	16750351-406	2	
	4		. WASHER, Lock No. 6	83910	1206-00	16750431-005	2	
	5		. WASHER, Flat No. 6	86928	5702-12-32	16755674-008	2	
			- - - * - - -					
	6	K1	. SOLENOID	73949	T-8	16775319-001	1	
			(ATTACHING PARTS)					
	7		. NUT (Part of NHA)			No Number	1	
	8		. WASHER, Star (Part of NHA)			No Number	1	
			- - - * - - -					
	9		. WIRE, Linkage			16805095-001	1	
			(ATTACHING PARTS)					
	10		. PIN, Roll 1/8 x 5/8 Long	72962	79-028-125-0625	16750292-060	1	
			- - - * - - -					
	11		. PLUNGER, Solenoid (Part of K1)			No Number	1	
	12		. WASHER, Shouldered			16775257-001	1	
	13		. SPRING, Helical, Compression			16760766-003	1	

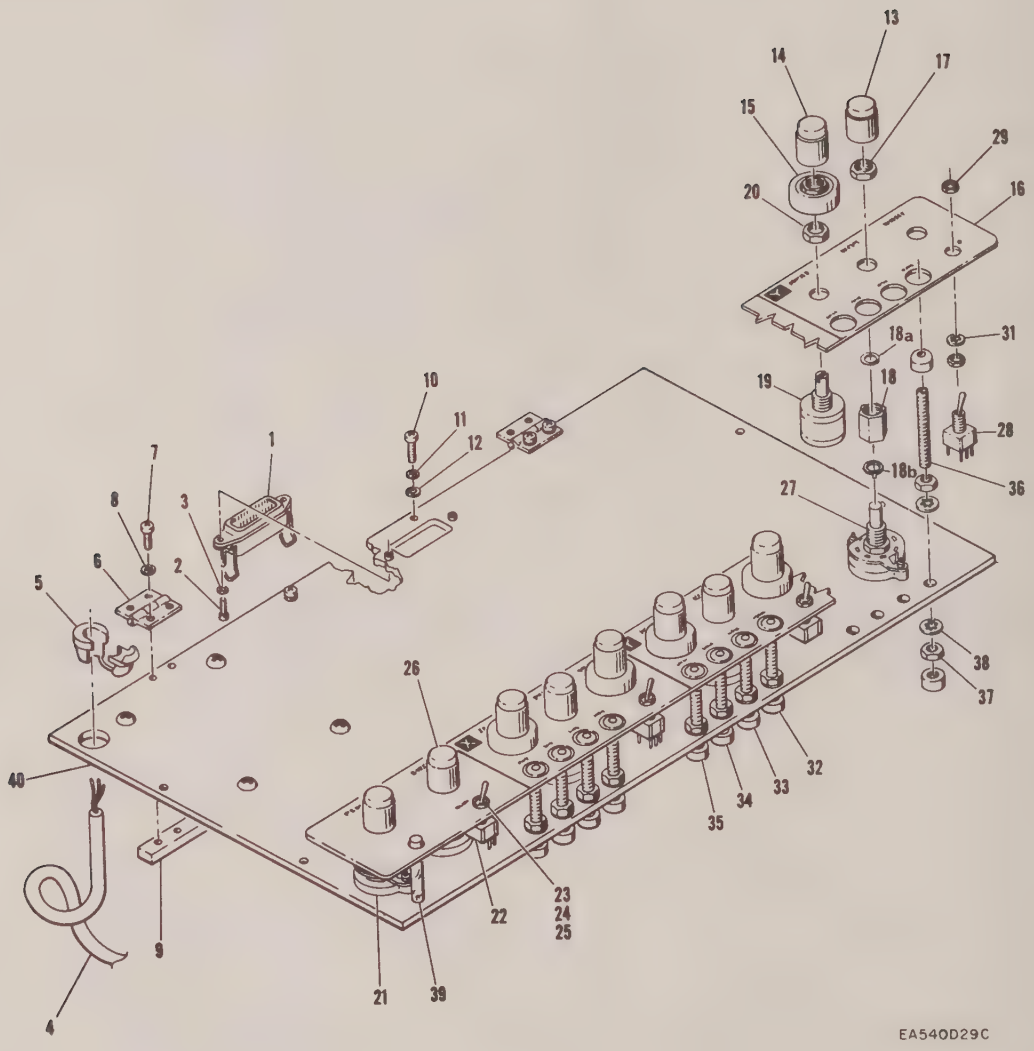


Figure 6-9. Mother Board Assembly

References			Description	Manufacturer's		E. A. Part No.	Qty/ Assy	Spares
Fig	Index	Schem		Code	Part Number			
			MOTHER BOARD ASSEMBLY (See Figure 6-1 for NHA)			16770951-XXX	REF	
6-9	1		. CONNECTOR, Receptacle, electrical, 24 pins	02660	57-30240	16750110-014	1	
			(ATTACHING PARTS)					
	2		. SCREW, F.H., 2-56 by 3/8 IN.	96906	MS35190-213	16765280-205	2	
	3		. WASHER, Flat, NO. 2	86918	5702-4-16	16755674-001	2	
			- - - * - - -					
	4		. CORD, Power			8935-G	1	
			(ATTACHING PARTS)					
	5		. CLAMP, Cord, Power	28520	SR6P	16750479-008	1	
			- - - * - - -					
	6		. HINGE			16773603-001	2	
			(ATTACHING PARTS)					
	7		. SCREW, P.H., 4-40 by 3/8 IN.	96906	MS35206-215	16765278-215	4	
	8		. WASHER, Lock, INT tooth, NO. 4	83910	1204-00	16750431-003	4	
			. WASHER, Flat, NO. 4			16755674-006	4	
			- - - * - - -					
	9		. STIFFENER, Board			16805067-001	1	
			(ATTACHING PARTS)					
	10		. SCREW, P.H., 4-40 by 1/4 IN.	96906	MS35206-213	16765278-213	2	
	11		. WASHER, Flat, NO. 4			16755674-006	2	
	12		. WASHER, Lock, INT tooth, NO. 4	83910	1204-00	16750431-003	2	
			- - - * - - -					
	13		. KNOB, Control, round	21604	PS-70-DL-2	16757252-411	5*	
	14		. KNOB, Control, round	21604	PS-70-2	16757252-611	6	
	15		. LOCK, Knob	21604	Order by description	16738444-101	6	
	16		. PANEL, Front, marked in inch units (Used on Model 540B only)			16771524-001	1	
	16		. PANEL, Front, time base, inches (Used on Model 540T only)			16770262-001	1	
	16		. PANEL, Front, marked in metric units (Used on Model 540M only)			16771525-001	1	
	16		. PANEL, Front, time base, metric (Used on Model 540TM only)			16771526-001	1	
			(ATTACHING PARTS)					
	17		. NUT (Part of items 21 and 27)			No Number	4	
	18		. STANDOFF, Hex, 3/8-32			16771872-001	4	
	18A		. WASHER, (Part of items 21 and 27)			No Number	4	
	18B		WASHER, Flat			12083	4	
	19	R119, R219, R319, R141, R241, R341	. RESISTOR, Variable, 10 turn, 10K, 2W, "ZERO" and "VARIABLE"	73138	7276R10K	16770158-007	6	2
			(ATTACHING PARTS)					
	20		. NUT (Part of NHA)			No Number	1	
			- - - * - - -					
	21	S1	. SWITCH, Rotary, 6 Pol., 4 Pos. "POWER"			16770957-002	1	
			. . SHIELD, Switch			16800400-001	1	
	22	S2	. SWITCH, Toggle, DPDT "RESET-START" (T, TM)	91929	2TW2-4	16771492-002	1	
			* Models 540 and 540M have four; Models 540T and 540TM have five.					

References			Description	Manufacturer's		E. A. Part No.	Qty/ Assy	Spares
Fig	Index	Schem		Code	Part Number			
6-9			(ATTACHING PARTS)					
	23		. NUT (Part of NHA)			No Number	2	
	24		. SOLDER LUG			16113062-001	1	
			(Part of NHA)					
			- - - * - - -					
	26	S3	. SWITCH, Rotary, 1 Pol., 8 Pos. "SWEEP RATE" (T,TM)			16800036-001	1	
	27	S101, S201, S301	. SWITCH, Rotary, 4 Pol., 6 Pos. "RANGE"			16770959-001	3	
			. . WAFER, Switch			16771816-001	3	
	28	S102, S202, S302	. SWITCH, Toggle, SPDT "FIXED - VARIABLE"	91929	1TW2-3	16771492-003	3	
			(ATTACHING PARTS)					
	29		. NUT (Part of NHA)			No Number	2	
	31		. WASHER, Lock, INT tooth (Part of NHA)			No Number	1	
			- - - * - - -					
	32		. CAP, Jack, black "GND"	83330	205-103	16100495-101	6	
	33		. CAP, Jack, blue "GUARD"	83330	205-105	16100495-105	6	
	34		. CAP, Jack, red "HIGH"	83330	205-102	16100495-102	6	
	35		. CAP, Jack, white "LOW"	83330	205-101	16100495-103	6	
	36		. POST, Jack, 1/4-32 by 1.812 IN. LG, 0.166 ID.			16805068-001	12	
			(ATTACHING PARTS)					
	37		. NUT, 1/4-32 x 1/16 IN. THK		COML	16750409-028	4	
	38		. WASHER, Lock, INT tooth, 1/4 IN.		COML	16756585-004	4	
			- - - * - - -					
	39		. LIGHT, Indicator, neon, 120 Vac	03797	CG21-CC-NEZE	16800134-001	1	
	40		. WIRING BOARD, Printed (See Figure 6-10 for detail)			16770950-003	1	

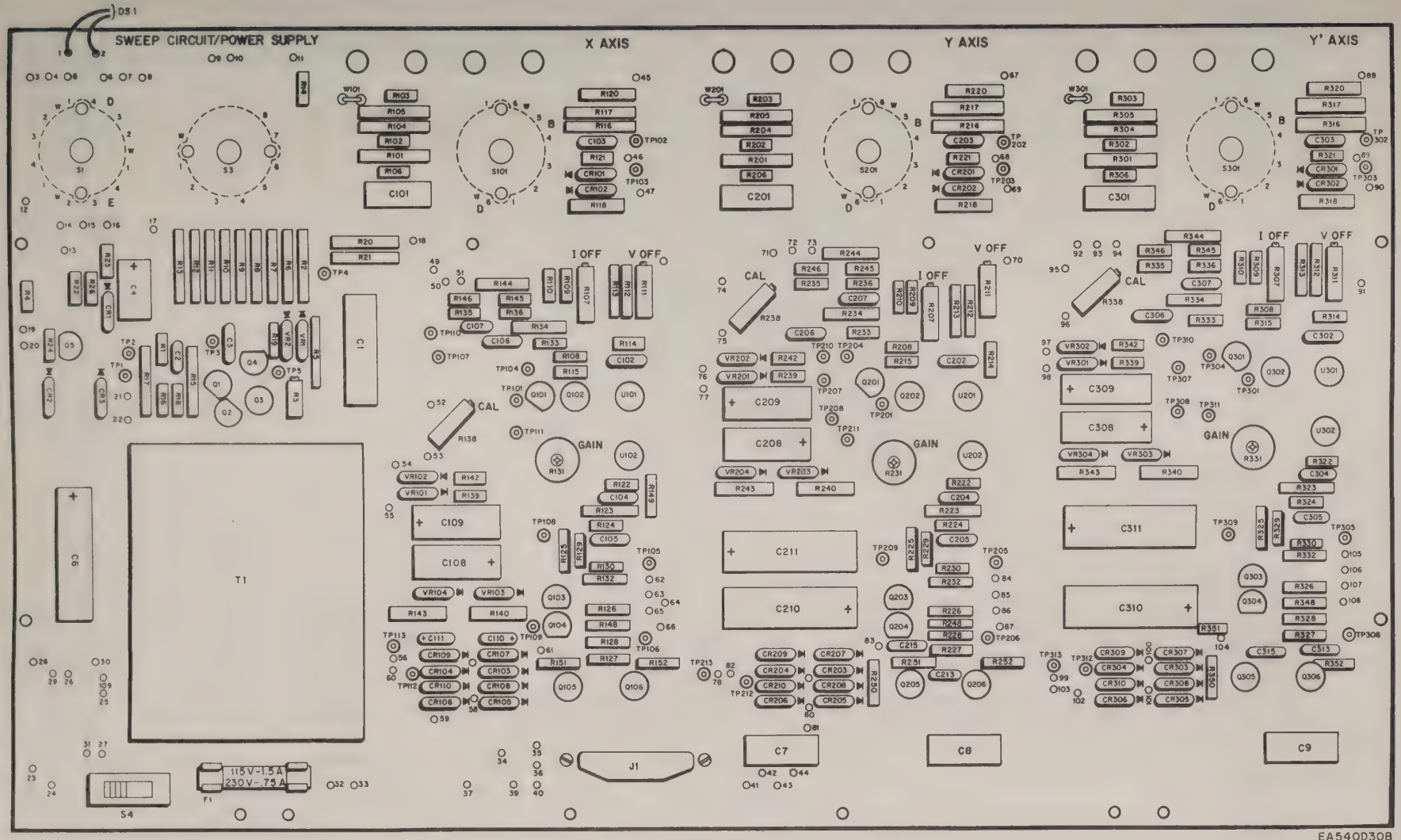


Figure 6-10. Mother Board Circuit Card Assembly
16773697

References			Description	Manufacturer's		E. A. Part No.	Qty/ Assy	Spares
Fig	Index	Schem		Code	Part Number			
			WIRING BOARD, Printed (See Figure 6-9 for NHA)			16770950-003	REF	
6-10		C1	. CAPACITOR, Fixed, 10UF, 200V (Used on Models 540T and 540TM only)	81349	CQ04A1TC103K1	16800058-001	1	
		C2	. CAPACITOR, Fixed, ceramic, .01UF, 50V (Used on Models 540T and 540TM only)	56289	C023B101F103Z	16757455-002	1	
		C3	. CAPACITOR, Fixed, ceramic, 0.1Uf, 50V (Used on Models 540T and 540TM only)	56289	33C41B5	16757455-008	1	
		C4	. CAPACITOR, Fixed, electrolytic, 100UF, 25V	56289	TE-1211	14440-100	1	1
		C5	. CAPACITOR, Fixed, ceramic, .01UF, 50V	56289	C023B101F103Z	16757455-002	1	
		C6	. CAPACITOR, Fixed, electrolytic, 1000UF, 50V	73445	2222-063-90041	16771653-002	1	1
		C7, C8, C9	. CAPACITOR, Fixed, mylar, .047UF, 600V	06001	75F6R6-473A	16770744-175	3	
		C101,C201, C301	. CAPACITOR, Fixed, mylar, 1UF, 50V	06001	75F7R5-105A	16770744-242	3	
		C302	. CAPACITOR, Fixed, mica, .001UF, 500V, ±5%	14655	CM06FD102J03	16761549-054	3	
		C103,C203, C303	. CAPACITOR, Fixed, ceramic, 10 UF, 15V	56289	33C41B5	16758058-234	3	
		C104,C204, C304	. CAPACITOR, Fixed, mylar, 0.27UF, 50V	06001	75F4R5-274A	16770744-235	3	
		C105,C205, C305	. CAPACITOR, Fixed, mica, .001UF, 500V, ±5%	14655	CM06FD102J03	16761549-054	3	
		C106	. CAPACITOR, Fixed, mylar, .033UF, 50V, ±5%	01002	75F1R5C-333	16763563-224	1	
		C107, C207, C307	. CAPACITOR, Fixed, mylar, 0.1UF, 250V		COML	CMM-40-008	3	
		C108, C208, C308, C109, C209, C309	. CAPACITOR, Fixed, electrolytic, 250UF, 25V	73445	C437ARF250	16758518-264	6	2
		C110, C111	. CAPACITOR, Fixed, ceramic, .01UF, 50V	56289	C023B101F103Z	16757455-002	2	
		C114, C214, C314	. Not Used Delete if installed					
		C206, C306	. CAPACITOR, Fixed, mylar, 0.027UF, 50VDC, ±5%	01002	75F1R5C273	16763563-223	2	
		C210, C310, C211, C311	. CAPACITOR, Fixed, electrolytic, 2000UF, 25V	73445	2222-063-90042	16771653-001	4	2
		C213, C313	. CAPACITOR, Fixed, ceramic, 0.01UF, 50V	56289	C023B101F103Z	16757455-002	2	
		C215, C315	. CAPACITOR, Fixed, ceramic, 0.01UF, 50V	56289	C023B101F103Z	16757455-002	2	

References			Description	Manufacturer's		E. A. Part No.	Qty/ Assy	Spares
Fig	Index	Schem		Code	Part Number			
6-10		CR1 thru CR3, CR103 thru CR110, CR203 thru CR210, CR303 thru CR310	. SEMICONDUCTOR DEVICE, Diode, silicon, general purpose	04713	IN4002	16756961-002	27	10
		CR101, CR201, CR301, CR102, CR202, CR302	. SEMICONDUCTOR DEVICE, Diode, silicon, switching	73760	IN4148	16756865-003	6	2
		F1	. FUSE, Cartridge, 1.5A, 0.250 by 1.250 IN. (For use on 115 Vac models only)	71400	MDX-1.500	16750231-031	1	5
		F1	. FUSE, Cartridge, 0.75A, 0.250 by 1.250 IN. (For use on 230 Vac models only)	71400	MDL-.750	16750231-029	1	5
		Q1, Q2	. TRANSISTOR, PNP, silicon (Used on Models 540T and 540TM only)	07263	2N4250	16765841-003	2	
		Q3	. TRANSISTOR, Field Effect, N-channel, dual (Used on Models 540T and 540TM only)	22229	2N3958	16769145-001	1	
		Q4	. TRANSISTOR, NPN, silicon (Used on Models 540T and 540TM only)	04713	2N3904	16762172-001	1	2
		Q5	. TRANSISTOR, NPN, silicon	04713	2N2219	16757925-003	1	
		Q101, Q201, Q301	. TRANSISTOR, PNP, silicon	07263	2N4250 7542	16765841-003	3	
		Q102, Q202, Q302	. TRANSISTOR, NPN, silicon, dual	32293	ITS1052	16773669-001	3	2
		Q103, Q203, Q303	. TRANSISTOR, NPN, silicon	04713	2N3904	16762172-001	3	
		Q104, Q204, Q304	. TRANSISTOR, PNP, silicon	04713	2N3906	16762173-001	3	1
		Q105, Q205, Q305	. TRANSISTOR, PNP, silicon	04713	2N4919	16766748-002	3	2
		Q106, Q206, Q306	. TRANSISTOR, NPN, silicon	04713	2N4922	16766748-005	3	2

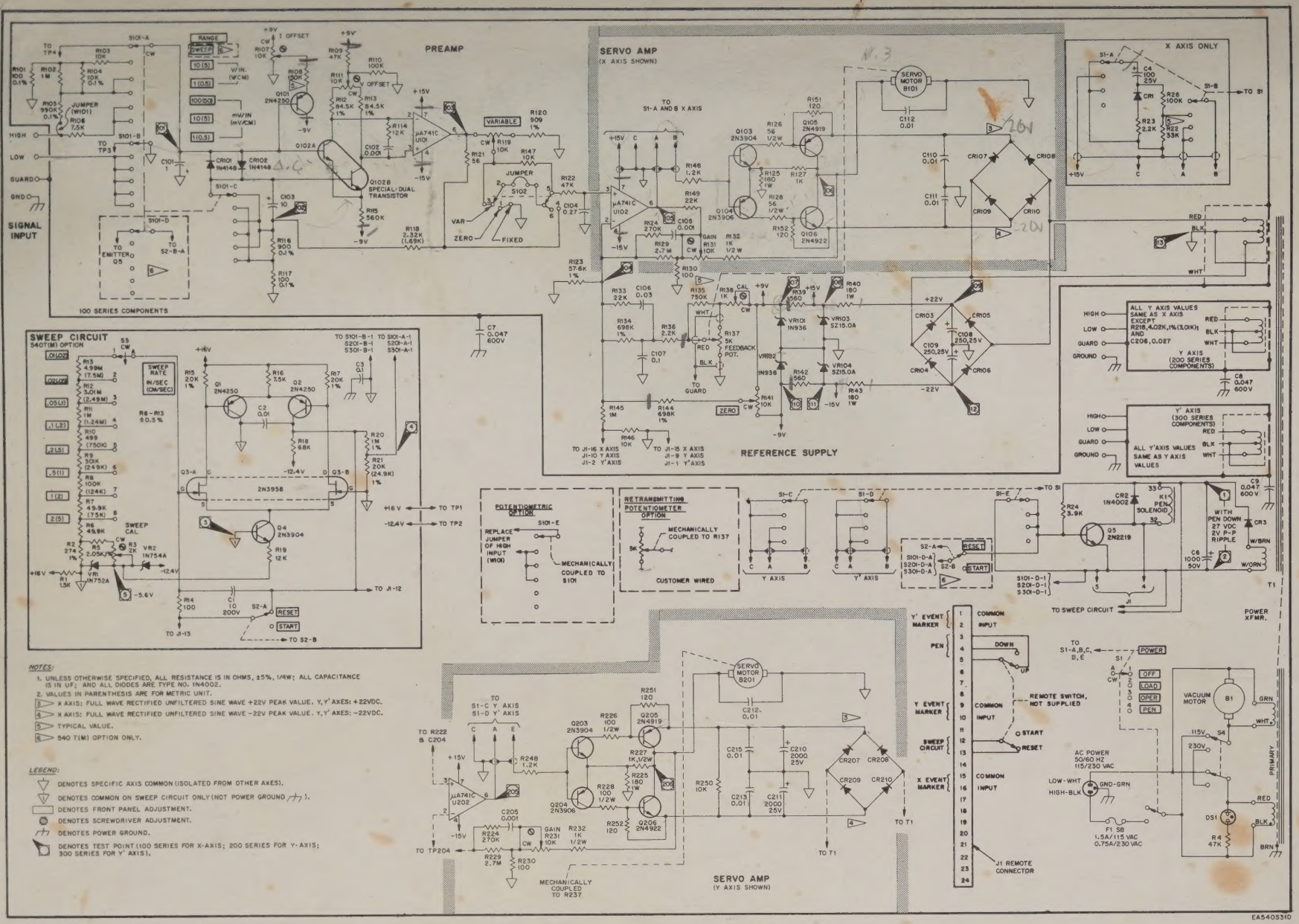
References			Description	Manufacturer's		E. A. Part No.	Qty/ Assy	Spares
Fig	Index	Schem		Code	Part Number			
6-10		R1	. RESISTOR, Fixed, carbon, 1.5K ohm, 1/4W, ±5% (T, TM)	81349	RC06GF152J	16750079-037	1	
		R2	. RESISTOR, Fixed, metal film, 274 ohm, 1/2-1W, ±1% (T, TM)	81349	RN70C2740F	16757166-143	1	
		R3	. RESISTOR, Variable, linear precision, metal film, 2K, ±10% (T, TM)	80294	3255W-1-202	16774578-108	1	
		R4	. RESISTOR, Fixed, carbon, 47K ohm, 1/4W, ±5%	81349	RC06GF473J	16750079-073	1	
		R5	. RESISTOR, Fixed, metal film, 2.05K ohm, 1/2-1W, ±1% (T, TM)	81349	RN70C2050F	16757166-231	1	
		R6	. RESISTOR, Fixed, metal film, 49.9K ohm, 1/2-1W, ±0.5% (T, TM)	81349	RN60C4992D	16800218-368	1	
		R7	. RESISTOR (same as R6) (T)			16800218-368	1	
		R7	. RESISTOR, Fixed, metal film, 75K ohm, 1/2-1W, ±0.5% (TM)	81349	RN60C7502D	16800218-385	1	
		R8	. RESISTOR, Fixed, metal film, 100K ohm, 1/2-1W, ±0.5% (T)	81349	RN60C1003D	16800218-401	1	
		R8	. RESISTOR, Fixed, metal film, 124K ohm, 1/2-1W, ±0.5% (TM)	81349	RN60C1243D	16800218-410	1	
		R9	. RESISTOR, Fixed, metal film, 301K ohm, 1/2-1W, ±0.5% (T)	81349	RN60C3013D	16800218-447	1	
		R9	. RESISTOR, Fixed, metal film, 249K ohm, 1/2-1W, ±0.5% (TM)	81349	RN60C2493D	16800218-439	1	
		R10	. RESISTOR, Fixed, metal film, 499K ohm, 1/2-1W, ±0.5% (T)	81349	RN60C4993D	16800218-468	1	
		R10	. RESISTOR, Fixed, metal film, 750K ohm, 1/2-1W, ±0.5% (TM)	81349	RN60C7503D	16800218-485	1	
		R11	. RESISTOR, Fixed, metal film, 1M ohm, 1/2-1W, ±0.5% (T)	81349	RN60C1004D	16800218-501	1	
		R11	. RESISTOR, Fixed, metal film, 1.24M ohm, 1/2-1W, ±0.5%	81349	RN60C1244D	16800218-510	1	
		R12	. RESISTOR, Fixed, film, 3.01M ohm, 1/2W, ±0.5% (T)	81349	RN65D3014D	16800685-612	1	
		R12	. RESISTOR, Fixed, film, 2.49M ohm, 1/2W, ±0.5% (TM)	81349	RN65D2494D	16800685-611	1	
		R13	. RESISTOR, Fixed, film, 4.99M ohm, 1/2W, ±0.5% (T)	81349	RN65D4994D	16800685-613	1	
		R13	. RESISTOR, Fixed, film, 7.5M ohm, 1/2W, ±0.5% (TM)	81349	RN65D7504D	16800685-614	1	
		R14	. RESISTOR, Fixed, carbon, 100 ohm, 1/4W, ±5% (T, TM)	81349	RC06GF101J	16750079-009	1	
		R15	. RESISTOR, Fixed, metal film, 20K ohm, 1/2-1W, ±1% (T, TM)	81349	RN70C2002F	16757166-330	1	
		R16	. RESISTOR, Fixed, carbon, 7.5K ohm, 1/4W, ±5% (T, TM)	81349	RC06GF752J	16750079-054	1	
		R17	. RESISTOR (same as R15) (T, TM)			16757166-330	1	
		R18	. RESISTOR, Fixed, carbon, 68K ohm, 1/4W, ±5% (T, TM)	81349	RC06GF683J	16750079-077	1	
		R19	. RESISTOR, Fixed, carbon, 12K ohm, 1/4W, ±5% (T, TM)	81349	RC06GF123J	16750079-059	1	
		R20	. RESISTOR, Fixed, metal film, 1M ohm, 1/2-1W, 1% (T, TM)	81349	RN70C1004F	16757166-501	1	
		R21	. RESISTOR, Fixed, carbon, 10K ohm . 1/4W, 5% (B, M)	81349	RC06GF103J	16750079-057	1	
		R21	. RESISTOR, (same as R15) (T)			16757166-330	1	
		R21	. RESISTOR, Fixed, metal film, 24.9K ohm, 1/2-1W, 1% (TM)	81349	RN70C2492F	16757166-339	1	
		R22	. RESISTOR, Fixed, carbon, 33K ohm, 1/4W, ±5%	81349	RC06GF333J	RCC10-333	1	
		R23	. RESISTOR, Fixed, carbon 2.2K ohm, 1/4W, ±5%	81349	RCG6GF222J	16750079-041	1	

References			Description	Manufacturer's		E. A. Part No.	Qty/ Assy	Spares
Fig	Index	Schem		Code	Part Number			
6-10		R24,R25	. RESISTOR, Fixed, carbon, 4.7K ohm, 1/4W, ±5%	81349	RC06GF472J	16750079-049	2	
		R26	. RESISTOR, Fixed, carbon, 100K ohm, 1/4W, ±5%	81349	RC06GF104J	16750079-081	1	
		R101, R201, R301	. RESISTOR, Fixed, metal film, 100 ohm, 1/2-1W, ±0.1%	81349	RN75C1000B	16800219-101	3	
		R102, R202, R302	. RESISTOR, Fixed, carbon, 1M ohm, 1/4W, ±5%	81349	RC06GF105J	16750079-105	3	
		R103, R203, R303	. RESISTOR, Fixed, carbon, 10K ohm, 1/4W, ±5%	81349	RC06GF103J	16750079-057	3	
		R104, R204, R304	. RESISTOR, Fixed, metal film, 10K ohm, 1/2-1W, ±0.1%	81349	RN75C1002B	16800219-301	3	
		R105, R205, R305	. RESISTOR, Fixed, metal film, 990K ohm, 1/2-1W, ±0.1%	81349	RN75C9903B	16800219-627	3	
		R106, R206, R306	. RESISTOR (Same as R16)			16750079-054	3	
		R107, R207, R307	. RESISTOR, Variable, ceramic, 10K ohm, 0.75W, 10%	73138	79PR10K	16765947-010	3	
		R108, R208, R308	. RESISTOR, Fixed, carbon, 330K ohm, 1/4W, ±5%	81349	RC06GF334J	16750079-093	3	
		R109, R209, R309	. RESISTOR (same as R4)			16750079-073	3	
		R110, R210, R310	. RESISTOR (same as R26)			16750079-081	3	
		R111, R211, R311	. RESISTOR (same as R107)			16765947-010	3	
		R112, R212, R312 R113, R213, R313	. RESISTOR, Fixed, wirewound, 84.5K ohm, 1/2W ±1%	81349	RN65D8452F	16757162-390	6	
		R114, R214, R314	. RESISTOR (same as R19)			16750079-059	3	

References			Description	Manufacturer's		E.A. Part No.	Qty/ Assy	Spares
Fig	Index	Schem		Code	Part Number			
6-10		R115, R215, R315	. RESISTOR, Fixed, carbon, 560K ohm, 1/4W, ±5%	81349	RC06GF564J	16750079-099	3	
		R116, R216, R316	. RESISTOR, Fixed, metal film, 900 ohm, 1/2-1W, ±0.1%	81349	RN75C9000B	16800219-608	3	
		R117, R217, R317	. RESISTOR (same as R101)			16800219-101	3	
		R118	. RESISTOR, Fixed, metal film, 2.32K ohm, 1/4-1/2W, ±1% (B, T)	81349	RN65C2321F	16757162-236	1	
		R118	. RESISTOR, Fixed, metal film, 1.69K ohm, 1/4-1/2W, ±1% (M, TM)	81349	RN65C1691F	16757162-223	1	
		R218, R318	. RESISTOR, Fixed, metal film, 4.02K ohm, 1/4-1/2W, ±1% (B, T)	81349	RN65C4021F	16757162-259	2	
		R218, R318	. RESISTOR, Fixed, metal film, 3.01K ohm, 1/4-13/W, ±1% (B, M, TM)	81349	RN65C3011F	16757162-247	2	
		R119, R219, R319	. See Figure 6-9					
		R120, R220, R320	. RESISTOR, Fixed, metal film, 909 ohm, 1/4-1/2W, ±1%	81349	RN65C9090F	16757161-193	3	
		R121, R221 R321	. RESISTOR, Fixed, carbon, 56 ohm, 1/4W, ±5%	81349	RC06GF560J	16750079-003	3	
		R122, R222, R322	. RESISTOR (same as R4)			16750079-073	3	
		R123, R223, R323	. RESISTOR, Fixed, metal film, 57.6K ohm, 1/4-1/2W, ±1%	81349	RN65C5761F	16757162-374	3	
		R124, R224, R324	. RESISTOR, Fixed, carbon, 270K ohm, 1/4W, ±5%	81349	RC06GF271J	16750079-091	3	
		R125, R225, R325	. RESISTOR, Fixed, carbon, 150 ohm, 1/4W, ±5%	81349	RC06GF151J	16750079-013	3	
		R126, R226, R326	. RESISTOR, Fixed, carbon, 56 ohm, 1/2W, ±5%	81349	RC20GF560J	16750076-519	3	

References			Description	Manufacturer's		E. A. Part No.	Qty/ Assy	Spares
Fig	Index	Schem		Code	Part Number			
6-10		R127, R227, R327	. RESISTOR, Fixed, carbon, 1K ohm, 1/2W, ±5%	81349	RC20GF102J	16750076-549	3	
		R128, R228, R328	. RESISTOR (same as R126)			16750076-519	3	
		R129, R229, R329	. RESISTOR, Fixed, Carbon, 2.7M ohm, 1/4W, ±5%	81349	RC06GF275J	16750079-115	3	
		R130, R230, R330	. RESISTOR, Fixed, carbon, 100 ohm, 1/4W, ±5%	81349	RC06GF101J	16750079-009	3	
		R131, R231, R331	. RESISTOR, Variable, wirewound, 10K ohm, 2W, ±20%	11236	TYPE 115	16755881-008	3	
		R132, R232, R332	. RESISTOR (same as R127)			16750076-549	3	
		R133, R233, R333	. RESISTOR, Fixed, carbon, 22K ohms, 1/4W, ±5%	81349	RC06GF2202J	16750079-065	3	
		R134, R234, R334	. RESISTOR, Fixed, metal film, 698K ohm, 1/4-1/2W, ±1%	81349	RN65C6983F	16757162-482	3	
		R135, R235, R335	. RESISTOR, Fixed, carbon, 750K ohm, 1/4W, ±5%	81349	RC06GF754J	16750079-102	3	
		R136, R236, R336	. RESISTOR (same as R23)			16750079-041	3	
		R138, R238, R338	. RESISTOR, Variable, wirewound, 1K ohms, 2W, ±20%	73138	78PR1K	52225-5	3	
		R139, R239, R339	. RESISTOR, Fixed, carbon, 560 ohms, 1/4W, ±5%	81349	RC06GF561J	16750079-027	3	
		R140, R240, R340	. RESISTOR, Fixed, carbon, 180 ohm, 1W, ±5%	81349	RC32GF181J	16750077-545	3	

References			Description	Manufacturer's		E.A. Part No.	Qty/ Assy	Spares
Fig	Index	Schem		Code	Part Number			
6-10		R142, R242, R342	. RESISTOR (same as R139)			16750079-027	3	
		R143, R243, R343	. RESISTOR (same as R140)			16750077-545	3	
		R144, R244, R344	. RESISTOR (same as R134)			16757162-482	3	
		R145, R245, R345	. RESISTOR (same as R102)			16750079-105	3	
		R146, R246, R346	. RESISTOR (same as R103)			16750079-057	3	
		R148	. RESISTOR, Fixed, carbon composition, 1.2K ohms, ±5%, 1/4W	81349	RC06GF122J	16750079-035	1	
		R149	. RESISTOR (same as R133)			16750079-065	1	
		R151, R152, R251, R252, R351, R352	. RESISTOR, Fixed, carbon composition, 120 ohms, 1/4W, ±5%			16750079-011	6	
		R248, R348	. RESISTOR, Fixed, carbon composition, 1.2K ohms, 1/4W, ±5%			16750079-035	2	
		R250, R350	. RESISTOR (same as R103)			16750079-057	2	
		S4	. SWITCH, Slide	82389	56256LF	16765838-001		
		T1	. TRANSFORMER	13786	60310	16770952-001	1	
		U101, U201, U301, U102, U202, U302	. INTEGRATED CIRCUIT, Operational amplifier, μA741C	07263	U6E7741393	16763333-004	6	2
		VR1	. SEMICONDUCTOR DEVICE, Diode, zener, 5.6V (T, TM)	04713	IN752A	16756688-060	1	
		VR2	. SEMICONDUCTOR DEVICE, Diode, zener, 6.8V (T, TM)	04713	IN754A	16756688-062	1	
		VR101, VR201, VR301, VR102, VR202, VR302	. SEMICONDUCTOR DEVICE, Diode, zener, 9V	04713	IN936	16757931-202	6	2
		VR103, VR203, VR303, VR104, VR204, VR304	. SEMICONDUCTOR DEVICE, Diode, zener, 15V	81071	SZ15.0A	16769141-001	6	3
		XF1	. FUSEHOLDER	75915	101001	16100028-001	2	



NOTES:

1. UNLESS OTHERWISE SPECIFIED, ALL RESISTANCE IS IN OHMS, ±5%, 1/4W; ALL CAPACITANCE IS IN UF; AND ALL DIODES ARE TYPE NO. 1N4002.
2. VALUES IN PARENTHESIS ARE FOR METRIC UNIT.
3. X AXIS: FULL WAVE RECTIFIED UNFILTERED SINE WAVE +22V PEAK VALUE. Y, Y' AXES: +22VDC.
4. X AXIS: FULL WAVE RECTIFIED UNFILTERED SINE WAVE -22V PEAK VALUE. Y, Y' AXES: -22VDC.
5. TYPICAL VALUE.
6. 540 T(M) OPTION ONLY.

LEGEND:

- DENOTES SPECIFIC AXIS COMMON (ISOLATED FROM OTHER AXES).
- DENOTES COMMON ON SWEEP CIRCUIT ONLY (NOT POWER GROUND).
- DENOTES FRONT PANEL ADJUSTMENT.
- DENOTES SCREWDRIVER ADJUSTMENT.
- DENOTES POWER GROUND.
- DENOTES TEST POINT (100 SERIES FOR X-AXIS; 200 SERIES FOR Y-AXIS; 300 SERIES FOR Y' AXIS).

EA5405310

Figure 6-11. Schematic

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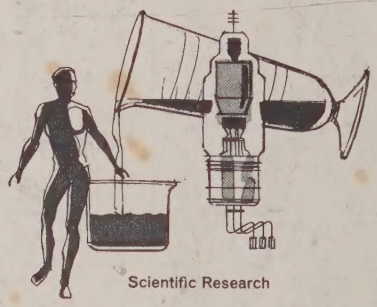
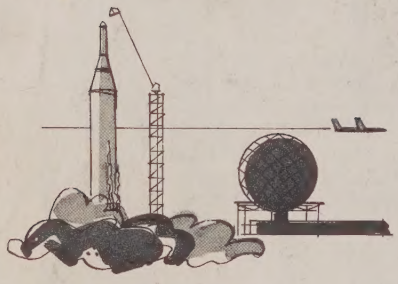
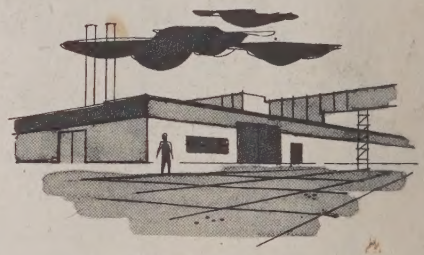


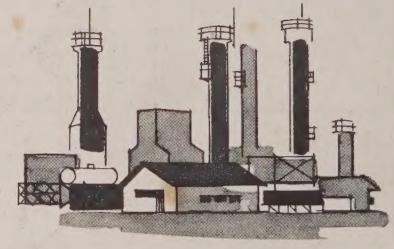
Scientific Research



Space Exploration



Production Analysis



Process Monitoring

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